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DIRECT TESTIMONY OF
BRENT R. KAWAKAMI, WITNESS FOR
AEP TEXAS INC. AND ONCOR ELECTRIC DELIVERY COMPANY LLC

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DIRECT TESTIMONY OF BRENT R. KAWAKAMI

I. POSITION AND QUALIFICATIONS

Q. PLEASE STATE YOUR NAME AND ADDRESS.

A. My name is Brent R. Kawakami. My business address is 2233-B Mountain Creek Parkway, Dallas, Texas 75211.

Q. PLEASE DESCRIBE YOUR JOB TITLE AND RESPONSIBILITIES.

A. I am employed by Oncor Electric Delivery Company LLC ("Oncor") as a Senior Engineer in Oncor's Transmission Planning group. I am responsible for the identification, initiation, and development of transmission projects in Oncor's West Texas service area, including the planning studies included in Oncor and AEP Texas Inc.'s ("AEP Texas") Far West Texas Project and Oncor's Far West Texas Project 2. My job duties also include calculating and maintaining the loading ratings for all autotransformers in Oncor's transmission system.

Q. PLEASE DESCRIBE YOUR PROFESSIONAL QUALIFICATIONS.

A. I have worked on the engineering of transmission infrastructure at Oncor for over 9 years, rising from Associate Engineer to Engineer to Staff Engineer to my current position as Senior Engineer. I am a licensed professional engineer in the State of Texas (#116905) and hold a bachelor's of science degree in electrical engineering from the University of Texas at Austin. My professional and educational qualifications are more fully presented in Exhibit BRK-1 attached hereto.

Q. HAVE YOU PREVIOUSLY SUBMITTED TESTIMONY BEFORE THE PUBLIC UTILITY COMMISSION OF TEXAS ("COMMISSION")?

A. Yes, I presented pre-filed and live testimony in Commission Docket Nos. 47368, 47808, and 48095.

II. PURPOSE OF TESTIMONY

Q. WHAT IS THE PURPOSE OF YOUR DIRECT TESTIMONY?

A. The purpose of my direct testimony is to describe the need for: (1) Oncor and AEP Texas' proposed Sand Lake – Solstice 345 kV transmission line project, and (2) AEP Texas and LCRA Transmission Services Corporation's ("LCRA TSC") Bakersfield – Solstice 345 kV transmission line project (together, "Proposed Transmission Line Projects"), including:

- submissions to and recommendations of the Electric Reliability Council of Texas, Inc. ("ERCOT") regarding the Proposed Transmission Line Projects;
- the adequacy of existing service;
- the need for additional service;
- how the Proposed Transmission Line Projects support the reliability and adequacy of the interconnected transmission system;
- how the Proposed Transmission Line Projects support robust wholesale competition;
- the probable improvement of service or lowering of cost to consumers in the area if the requested certificates of convenience and necessity ("CCNs") for the Proposed Transmission Line Projects are granted;
- the effect of granting the requested CCNs on Oncor, AEP Texas, LCRA TSC, and any electric utility serving the proximate area; and
- presentation and comparison of alternatives to the Proposed Transmission Line Projects.

These issues are addressed in responses to Question Nos. 14-16 in (1) Oncor and AEP Texas' CCN Application regarding the Sand Lake – Solstice line and (2) AEP Texas and LCRA TSC's CCN Application regarding the Bakersfield – Solstice line (Oncor, AEP Texas, and LCRA TSC are collectively referred to as "Applicants"). These two CCN Applications are being filed with the Commission contemporaneously, and my direct testimony in support of each Application is materially identical. The facts and statements set forth in response to Question Nos. 14-16 in each of the Applications, which I sponsor, are true and correct. I also sponsor Attachment Nos. 4-11 in the Sand Lake – Solstice project's CCN

Application and Attachment Nos. 2a – 2g in the Bakersfield – Solstice project's CCN Application. These Applications, as they may be amended and/or supplemented, and their attachments will be offered into evidence by Applicants as exhibits at their respective hearings on the merits.

Q. ON WHOSE BEHALF ARE YOU TESTIFYING?

A. Because my testimony focuses on the inter-related need for both of the Proposed Transmission Line Projects, I am testifying in both CCN proceedings on behalf of all three Applicants. Specifically, with respect to the Bakersfield – Solstice 345 kV transmission line project, I am testifying on behalf of the co-applicants in that proceeding, AEP Texas and LCRA TSC. With respect to the Sand Lake – Solstice 345 kV transmission line project, I am testifying on behalf of the co-applicants in that proceeding, AEP Texas and Oncor.

III. <u>AREA AND PROJECT DESCRIPTIONS</u>

Q. PLEASE GENERALLY DESCRIBE THE EXISTING TRANSMISSION SYSTEM IN THE AREA.

A. Pecos, Reeves, and Ward Counties lie within Far West Texas where oil and gas exploration and production activity in producing basins has driven the rapid growth of electric load in the area. Currently, the Sand Lake – Solstice project area is principally served by Oncor's Wink – Culberson and Yucca Drive – Culberson 138 kV transmission lines (together, "Culberson Loop lines"), Texas New Mexico Power's ("TNMP") 138 kV and 69 kV lines that terminate at the IH-20 Switch Station, and AEP Texas' 138 kV lines that terminate at the Solstice Switch Station. The Bakersfield – Solstice project area, known as the "Barilla Junction" area, is also served by existing 69 and 138 kV lines that run from the Solstice and Barilla Junction Stations to the Rio Pecos Switch Station. The map of the relevant area for the project subject to this proceeding is included as Exhibit BRK-2 hereto. The schematic of the transmission systems relevant to the project subject to this proceeding is included as Exhibit

BRK-3 hereto.

Q. PLEASE DESCRIBE THE PROPOSED TRANSMISSION LINE PROJECTS.

A. Both Proposed Transmission Line Projects are planned for construction on 345 kV double-circuit lattice steel structures. Both circuits of the Sand Lake – Solstice line will connect Oncor's planned Sand Lake Switch Station in Ward County ("Sand Lake") to AEP Texas's Solstice Switch Station in Pecos County ("Solstice"). Both circuits of the Bakersfield – Solstice line will connect LCRA TSC's existing Bakersfield Station in Pecos County ("Bakersfield") to Solstice.

IV. NEED FOR THE PROPOSED TRANSMISSION LINE PROJECTS

Q. PLEASE PROVIDE AN OVERVIEW OF THE NEED FOR THE PROPOSED TRANSMISSION LINE PROJECTS.

A. The Proposed Transmission Line Projects are needed to: (1) support load growth in the area; (2) address reliability violations under ERCOT reliability criteria and North American Electric Reliability Corporation ("NERC") reliability standards; and (3) provide the infrastructure necessary to facilitate future transmission system expansion.

A. LOAD GROWTH AND RELIABILITY

Q. HOW DO THE PROPOSED TRANSMISSION LINE PROJECTS ADDRESS CONTINUED LOAD GROWTH IN THE AREA?

A. The Far West Texas area is experiencing rapidly growing load due primarily to oil and natural gas production, processing, and transportation, as well as associated economic expansion. On the nearby Culberson Loop lines, Oncor has experienced large load increases in recent years. Between 2012 and 2017, the load on these transmission lines rose from 29.3 megawatts ("MW") to 246.4 MW. As of October 2018, the current highest recorded real-time value based on telemetry data for 2018 has been 395 MW. Oncor projects this strong load growth will continue.

Based solely on actual load increases for Oncor substations and confirmed customer load increases (based on financially committed customer contracts), Oncor projects end of year 2018 loads on these lines to increase to 771 MW, with 2019 non-coincident summer peak load on these lines of 902 MW, and ultimately 1,549 MW of non-coincident summer peak load on these lines by 2022, as shown in more detail below.

Projected Load on Culberson Loop, in Megawatts (based only on financially committed customer contracts)					
2018	2019	2020	2021	2022	2023
771	902	1,318	1,475	1,549	1,597

If the load projection parameters expand to take into account pending requests that are currently being studied and contractually negotiated between Oncor and customers, there is a probable likelihood of even further growth for non-coincident summer peak loads based on updated Oncor projections as of October 2018: for 2020, it grows to 1,406 MW; for 2021, it grows to 1,563 MW; and for 2022, it grows to 1,639 MW. Details on these load projections are included in response to Question No. 14 of the Applications for both projects.

Q. HOW HAS ONCOR'S PROJECTED LOAD ON THE CULBERSON LOOP CHANGED IN THE RECENT PAST?

A. Over the course of Commission Docket Nos. 47368 and 48095 regarding the Riverton – Sand Lake 345/138 kV transmission line, Odessa EHV – Riverton 345 kV transmission line, and Moss – Riverton 345 kV transmission line, the load projections provided in the applications and testimony supporting those projects consistently rose. These rising load projections reflect the increased number of customers executing agreements for service backed by financial security. Many of these customers are requesting service to support the booming oil and gas development in this area.

Q. HAVE STUDIES BEEN PERFORMED TO ASSESS RELIABILITY ISSUES IN THE AREA TRANSMISSION SYSTEM?

A. Yes. ERCOT performed steady state and dynamic stability power flow studies during each of its independent reviews of the Far West Texas Project and Far West Texas Project 2, and in each case it found multiple violations under NERC Reliability Standard TPL-001-4. Specifically, ERCOT's steady state analysis when reviewing the Far West Texas Project identified: thermal violations on multiple lines in the Barilla Junction Area under single contingencies in both generation cases it studied; unsolvable contingencies; and various voltage violations and unacceptable voltage deviations in the Culberson Loop under one or both cases studied. Unsolved contingencies are important—they mean that the transmission system cannot maintain acceptable voltage levels during an outage, resulting in potential voltage collapse and the dropping of substantial or all load along the Culberson Loop. ERCOT noted that its recommendations would enable the Culberson Loop to reliably serve load up to 717 MW.

Once contractually confirmed load projections surpassed ERCOT's previously-stated 717 MW threshold on the Culberson Loop, Oncor submitted and ERCOT studied the Far West Texas Project 2. ERCOT's steady state analysis when reviewing the Far West Texas Project 2 identified unsolvable contingencies and various voltage violations under certain contingencies within the Culberson Loop. Additionally, ERCOT identified pre-contingency voltage stability issues without the approved elements in the Far West Texas Project in-service. Notably, ERCOT's Far West Texas Project 2 independent review assumed that all previously-endorsed components of the Far West Texas Project (including one of the Bakersfield – Solstice 345 kV circuits) would already be in service.

Q. HOW WILL THE PROPOSED TRANSMISSION LINE PROJECTS ADDRESS RELIABILITY IN THE STUDY AREA?

A. The Proposed Transmission Line Projects will address the reliability concerns ERCOT identified in its studies by creating a strong source, a new 345 kV injection, to support voltage conditions in the area. Specifically, the projects will help address the unacceptable voltage conditions identified under multiple contingencies along the Culberson Loop transmission lines and the thermal violations observed on the Barilla Junction Area transmission lines. The Proposed Transmission Line Projects, in conjunction with the other components of the Far West Texas Project and the Far West Texas Project 2, will address the reliability criteria violations identified in ERCOT's independent reviews of both suites of projects.

B. ERCOT REVIEW: FAR WEST TEXAS PROJECT

Q. PLEASE PROVIDE AN OVERVIEW OF ERCOT'S INITIAL REVIEW AND ENDORSEMENT OF THE BAKERSFIELD – SOLSTICE 345 KV LINE.

A. In April 2016, Oncor and AEP Texas submitted for review by ERCOT's Regional Planning Group ("RPG") a suite of projects known as the "Far West Texas Project." A copy of Oncor and AEP Texas' ERCOT submittal for the Far West Texas Project is included as Exhibit BRK-4 attached hereto.

In June 2017, ERCOT's Board of Directors endorsed, among other things, a variation of the proposed Far West Texas Project to include a new 345 kV transmission line extending from Bakersfield to Solstice, to be built on double-circuit-capable 345 kV structures with one 345 kV circuit initially installed, as well as an expansion of Solstice to include the installation of a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers. A copy of ERCOT's independent review of the Far West Texas Project is included as Exhibit BRK-5 attached hereto.

Q. HOW WAS THE NEED FOR THE BAKERSFIELD – SOLSTICE LINE INITIALLY DETERMINED?

A. AEP Texas initially determined the need for a portion of the Far West

Texas Project, including a variation of the Bakersfield – Solstice line, in its internal transmission planning processes. At the time of the submittal in April 2016, AEP Texas projected load growth in the Barilla Junction area southwest of Odessa, which is mainly served by 69 and 138 kV lines. The historical and currently projected load on the Barilla Junction lines are contained in response to Question 14 of the Bakersfield – Solstice project Application.

Due to these identified needs in 2016, Oncor and AEP Texas jointly submitted the Far West Texas Project to ERCOT's RPG process in April 2016. The submittal recommended the development of a new 345 kV transmission path between the Bakersfield, Solstice, Sand Lake, Riverton and Odessa EHV stations.

Q. HOW DID ERCOT REVIEW THE FAR WEST TEXAS PROJECT PROPOSAL?

A. Oncor and AEP Texas submitted the Far West Texas Project through ERCOT's RPG process. ERCOT staff conducted an independent review of the proposed project.

Q. HOW DID ERCOT'S INDEPENDENT REVIEW OF THE FAR WEST TEXAS PROJECT ANALYZE THE POTENTIAL NEED FOR ADDITIONAL TRANSMISSION FACILITIES IN THE STUDY AREA?

A. ERCOT conducted steady state and dynamic stability power flow analyses using as its base case the 2021 West/Far West Texas summer peak case from the 2016 Regional Transmission Plan ("RTP") and the 2022 Dynamic Working Group summer peak flat start cases. In addition to the base case, ERCOT also used a "no solar generation" scenario and various other potential load sensitivities in its analyses. The results indicated that there was an unsolved contingency and local voltage stability challenges in the Culberson Loop area. The results also indicated that under N-1 contingency conditions, there were thermal and voltage violations on numerous transmission elements under NERC's TPL-001-4 reliability standard. NERC defines an N-1 contingency condition as removing one transmission element (such as a line segment, autotransformer, etc.) from service in the area to evaluate whether the remaining transmission lines in the area can still provide adequate service based on thermal and voltage considerations. Therefore, ERCOT determined there was a reliability need in the study region.

Q. WHAT OPTIONS DID ERCOT EVALUATE TO RESOLVE THE NERC VIOLATIONS IT FOUND?

A. ERCOT evaluated 40 alternatives based on variations of about 9 different transmission solutions. From those 9 major solution options, ERCOT used cost and reliability performance comparisons to narrow its analysis to four short-listed options to resolve the identified NERC violations. Three of the four options included the Solstice expansion and Bakersfield – Solstice 345 kV line components that ERCOT ultimately approved, while one of the options did not include either and focused on new 138 kV line construction and installation of capacitor banks and dynamic synchronous condensers at existing stations. The details of these four short-listed options, which ranged in estimated costs from $336 million to $501 million, are included in ERCOT's independent review of the Far West Texas Project.

Q. DID ERCOT FURTHER ANALYZE THE FOUR SHORT-LISTED OPTIONS?

A. ERCOT performed a steady state contingency analysis, voltage stability analysis, and economic analysis. After selecting its recommended option, ERCOT also performed steady-state performance tests, dynamic performance simulations, and sensitivity studies under various generation and load scenarios.

Q. WHAT WERE THE RESULTS OF ERCOT'S INDEPENDENT REVIEW FOR THE FAR WEST TEXAS PROJECT?

A. Ultimately, ERCOT determined there is a reliability need to improve the transmission system in Far West Texas. It concluded that the second option it evaluated was the most effective solution to meet the demonstrated reliability needs in the most cost effective manner while also providing multiple expansion paths to accommodate future load growth in the study area. While ERCOT noted that the second option did not meet the system reliability criteria under the potential load scenarios forecasted by the proposing utilities, selection of the second option allowed for deferral of more than $100 million in capital expenditures while allowing for a number of different expansion options that could augment the load serving capability of the second option as the outlook for greater load and generation resources in the region became clearer. Specifically, ERCOT stated that the third and fourth options could possibly be constructed from the second option to meet applicable transmission planning criteria while serving significantly higher loads in the region—717 MW of Culberson Loop load under the second option it selected, compared to 917 MW and 1,037 MW for the third and fourth options, respectively.

Q. WHAT COMPONENTS OF THE FAR WEST TEXAS PROJECT WERE INCLUDED IN THE SECOND OPTION ENDORSED BY ERCOT?

A. ERCOT's Board of Directors endorsed construction of, among other things, the following components relevant to these proceedings: (i) a new 345 kV transmission line extending from Bakersfield to Solstice, to be built by LCRA TSC and AEP Texas on double-circuit-capable 345 kV structures with one 345 kV circuit initially installed, and (ii) expansion of Solstice to include the installation of a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers. ERCOT also approved the following additional components: (i) expansion of the Riverton Switch station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers; and (ii) Oncor's construction of a new 345 kV line on double-circuit structures with one circuit initially in place from Moss – Riverton and use the vacant circuit position on the Moss – Odessa

EHV 345 kV double circuit structures to create the Odessa EHV – Riverton 345 kV line, including new 345 kV circuit breakers at Odessa EHV Switch. These endorsements were made as Tier 1 projects needed to support the reliability of the ERCOT transmission system, with support from all market segments throughout the RPG process and additional review by the Technical Advisory Committee.

ERCOT included the Far West Texas Project, including the Bakersfield – Solstice line, in its 2017 Report on Existing and Potential Electric System Constraints and Needs attached hereto as Exhibit BRK-6. ERCOT mentions the Bakersfield – Solstice line on page 16 of the report as one of the significant improvements planned for completion in 2022, and it mentions the Far West Texas Project generally on page 20 of the report as a major Permian Basin-related project.

Q. WHAT HAS OCCURRED IN FAR WEST TEXAS SINCE ERCOT ENDORSED THE FAR WEST TEXAS PROJECT?

A. Since ERCOT's approval of the Far West Texas project, Oncor has continued to experience unprecedented load growth in the area, as the historical and projected load numbers discussed above demonstrate. To alleviate the reliability issues identified on the Culberson Loop, Oncor has certificated the Riverton – Sand Lake 345/138 kV transmission line and the Odessa EHV – Riverton / Moss – Riverton 345 kV transmission line. Construction has commenced on the former and will soon commence on the latter.

Q. WHAT STEPS WERE TAKEN TO FURTHER BOLSTER THE ELECTRIC INFRASTRUCTURE IN THE AREA?

A. Given these continuing load increases past the thresholds ERCOT discussed in its independent review of the Far West Texas project, the Applicants determined that additional transmission infrastructure would be needed in the area. Therefore, in cooperation with AEP Texas and LCRA TSC, Oncor proposed the Far West Texas Project 2 to ERCOT.

C. ERCOT REVIEW: FAR WEST TEXAS PROJECT 2

Q. PLEASE PROVIDE AN OVERVIEW OF ERCOT'S REVIEW AND ENDORSEMENT OF THE SAND LAKE – SOLSTICE 345 KV LINE AND THE SECOND 345 KV CIRCUIT FOR THE BAKERSFIELD – SOLSTICE LINE.

A. In February 2018, Oncor submitted for RPG review a suite of projects known as the "Far West Texas Project 2." A copy of the ERCOT submittal regarding the Far West Texas Project 2 is included as Exhibit BRK-7 attached hereto. Following that submittal, Applicants sent a letter to ERCOT requesting critical designation for various projects, a copy of which is included as Exhibit BRK-8 attached hereto.

In June 2018, ERCOT's Board of Directors endorsed, among other things, a variation of the proposed Far West Texas Project 2 to include the Sand Lake – Solstice double-circuit 345 kV line and a second circuit on the Bakersfield – Solstice line, and it endorsed them as a Tier 1 transmission project needed to support the reliability of the ERCOT transmission system. A copy of ERCOT's Independent Review and recommendations regarding the Far West Texas Project 2 is included as Exhibit BRK-9 attached hereto.

As approved by ERCOT, the Far West Texas Project 2 includes the following components relevant to the Proposed Transmission Line Projects: (i) expansion of the Sand Lake Switching Station to install two new 600 MVA, 345/138 kV autotransformers; (ii) construction of an approximately 40-mile, 345 kV transmission line on double-circuit structures, with two circuits in place between Sand Lake and Solstice; and (iii) installation of a second 345 kV circuit on the Bakersfield – Solstice line.

In June 2018, ERCOT's Board of Directors also designated the Sand Lake – Solstice and Bakersfield – Solstice 345 kV lines as critical to the reliability of the ERCOT transmission system. A copy of ERCOT's resolution endorsing the Sand Lake – Solstice and Bakersfield – Solstice 345 kV lines as critical to reliability is included as Exhibit BRK-10 attached hereto.

Q. HOW WAS THE NEED FOR THE SAND LAKE – SOLSTICE LINE INITIALLY DETERMINED?

A. Oncor and AEP Texas initially determined the need for the Sand Lake – Solstice line in their internal transmission planning processes. During ERCOT's independent review of the Far West Texas Project, however, ERCOT determined this line would be potentially needed when load on the Culberson Loop surpassed 717 MW. As projected load on the Culberson Loop has continued to grow past that threshold, Oncor submitted the Far West Texas Project 2 to ERCOT's RPG process in February 2018. The relevant components of Oncor's submittal proposed construction of a new, 40-mile Sand Lake – Solstice double-circuit-capable 345 kV line (with one 345 kV circuit initially installed), as well as expansion of Sand Lake to install two new 600 MVA, 345/138 kV autotransformers.

Q. HOW DID ERCOT REVIEW THE SAND LAKE – SOLSTICE LINE?

A. ERCOT staff conducted an independent review of the Far West Texas Project 2, including the Sand Lake – Solstice line.

Q. HOW DID ERCOT'S INDEPENDENT REVIEW OF THE FAR WEST TEXAS PROJECT 2 ANALYZE THE POTENTIAL NEED FOR ADDITIONAL TRANSMISSION FACILITIES IN THE STUDY AREA?

A. ERCOT conducted steady state and dynamic stability power flow analyses using as its base case the 2020 West/Far West Texas summer peak case from the 2017 RTP and the 2020 Dynamic Working Group summer peak flat start cases. In addition to the base case, ERCOT also used a "no solar generation" scenario in its analyses. ERCOT's analysis showed pre-contingency voltage stability issues with no transmission upgrades. Even with the assumed addition of all ERCOT's previously-endorsed components of the Far West Texas Project, the results indicated both voltage violations and voltage collapse under certain contingencies for the projected Culberson Loop 2019 summer peak load. This analysis indicated that under N-1 contingency conditions, there were thermal violations on other transmission lines outside the Culberson Loop and voltage instability violations within the Culberson Loop under NERC's TPL-001-4 reliability standard. Therefore, ERCOT determined there was a reliability need in the study region.

Q. WHAT OPTIONS DID ERCOT EVALUATE TO RESOLVE THE NERC VIOLATIONS IT FOUND?

A. ERCOT evaluated several alternatives to resolve the violations discovered in its analysis. The alternatives considered were limited to those that aligned with the expansions already planned as part of the Far West Texas Project. Based on these considerations, ERCOT used cost and reliability performance comparisons to narrow its analysis to three short-listed options to resolve the identified NERC violations. Each of the three short-listed options included these same universal transmission upgrades: construct a new, approximately 40-mile Sand Lake – Solstice 345 kV line on double-circuit structures with two circuits in place; expansion of Sand Lake to install two new 600 MVA, 345/138 kV autotransformers; installation of a new 345 kV circuit on the planned Riverton – Sand Lake line; addition of a second 345 kV circuit to the Odessa EHV – Riverton 345 kV line structures (connecting Moss Switch Station and Riverton); addition of a second 345 kV circuit to the Solstice – Bakersfield 345 kV line; construction of a new Quarry Field 138 kV Switch Station in the Wink – Riverton double-circuit 138 kV line; construction of a new 20-mile Kyle Ranch – Riverton 138 kV line on double-circuit structures, with one circuit in place; and construction of a new 20-mile Owl Hills – Tunstill – Riverton 138 kV line on double-circuit structures, with one circuit in place. The three short-listed options also included the following unique features:

- The first option involved: installing two 250 MVAR Static Synchronous Compensators (STATCOMs) at Horseshoe Springs 138 kV Switch Station. The total estimated cost for this option was approximately $300 million.
- The second option involved: installing one 250 MVAR STATCOM at Horseshoe Springs 138 kV Switch Station; and installing capacitor banks with a total capacity of 150 MVAR at the Horseshoe Springs and Quarry Field Switch Stations. The total estimated cost for this option was approximately $292.5 million.
- The third option involved: installing one 250 MVAR STATCOM each at the Horseshoe Springs and Quarry Field Switch Stations; and installing capacitor banks with a total capacity of 150 MVAR at the Horseshoe Springs and Quarry Field Switch Stations. The total estimated cost for this option was approximately $327.5 million.

Q. DID ERCOT FURTHER ANALYZE THE THREE SHORT-LISTED OPTIONS?

A. ERCOT performed a steady state contingency analysis, voltage stability analysis, and economic analysis. After selecting its recommended option, ERCOT also performed steady-state performance tests, dynamic performance simulations, and sensitivity studies under various generation and load scenarios.

Q. WHAT WERE THE RESULTS OF ERCOT'S INDEPENDENT REVIEW FOR THE FAR WEST TEXAS PROJECT 2?

A. Ultimately, ERCOT determined there is a reliability need to improve the transmission system in Far West Texas. It concluded that the third option it evaluated was the most effective solution to meet the demonstrated reliability needs in the most cost effective manner while also providing multiple expansion paths to accommodate future load growth in the study area. Both the first and second options would require additional operational mitigation measures beyond the planned reactive devices prior to the new transmission lines being put in place. ERCOT recommended the reactive support components of the third option be implemented by 2019, if feasible, to avoid the need for additional remedial operational schemes to accommodate the projected Culberson Loop load of approximately 880 MW in summer 2019.

Q. WHAT COMPONENTS OF THE FAR WEST TEXAS PROJECT 2 DID ERCOT ENDORSE?

A. ERCOT recommended approval of a variation of the project submitted to RPG. ERCOT's Board of Directors endorsed, among other things, the following components relevant to these proceedings: (i) AEP Texas and Oncor's construction of two 345 kV circuits on the Sand Lake – Solstice line; (ii) addition of two autotransformers to Sand Lake as proposed in the RPG submittal; and (iii) addition of a second 345 kV circuit to the Solstice – Bakersfield 345 kV line. These endorsements were made as Tier 1 projects needed to support the reliability of the ERCOT transmission system, with support from all market segments throughout the RPG process and additional review by the Technical Advisory Committee.

Q. FOLLOWING ITS INDEPENDENT REVIEW OF FAR WEST TEXAS PROJECT 2, DID ERCOT FURTHER EVALUATE THE PROPOSED TRANSMISSION LINE PROJECTS?

A. Yes. Among other things, ERCOT's Board of Directors evaluated whether to endorse the Proposed Transmission Line Projects as critical to reliability, in response to a request from Applicants. The Applicants' letter request noted, among other things, the increased load projections Oncor had made since ERCOT's Independent Review of the Far West Texas Project 2. On June 12, 2018, ERCOT's Board unanimously adopted a resolution endorsing the Sand Lake – Solstice and Bakersfield – Solstice 345 kV lines as critical to the reliability of the ERCOT system pursuant to 16 Texas Administrative Code ("TAC") § 25.101(b)(3)(D). While I am not an attorney or legal expert, it is my understanding that under 16 TAC

§25.101(b)(3)(A), ERCOT's recommendation of the Far West Texas Project 2, including the Sand Lake – Solstice 345 kV line, is entitled to great weight.

D. OTHER ISSUES

Q. WILL THE PROPOSED TRANSMISSION LINE PROJECTS FACILITATE ROBUST WHOLESALE COMPETITION?

A. Yes. The Proposed Transmission Line Projects will facilitate robust wholesale competition by facilitating the delivery of economical electric power at 345 kV from existing and future generation resources located both inside and outside of the projects' study areas to existing and future electric customers in those areas. They will also deliver power through the 345 kV transmission system to areas that are not currently served at this voltage.

Q. WILL THE PROPOSED TRANSMISSION LINE PROJECTS FOSTER COMPETITION IN THE RETAIL MARKET?

A. Yes. The Proposed Transmission Line Projects will improve transmission service through areas where retail competition is available.

Q. WILL THE PROPOSED TRANSMISSION LINE PROJECTS AFFECT ANY ELECTRIC UTILITIES IN THE AREA OTHER THAN APPLICANTS?

A. Yes. TNMP has existing and future plans for points of interconnection to serve retail customers along Oncor's Yucca Drive – Culberson line, which is part of the Culberson Loop. The Proposed Transmission Line Projects' reliability benefits and operational flexibility would extend to TNMP's customers as well. Since the Proposed Transmission Line Projects will be connecting segments of a planned 345 kV loop of the area, each segment of the Sand Lake – Solstice – Bakersfield 345 kV lines will affect all of the Applicants.

V. <u>ALTERNATIVES CONSIDERED</u>

Q. WHAT ALTERNATIVES TO THE BAKERSFIELD – SOLSTICE LINE WERE STUDIED?

A. ERCOT studied four primary options in its independent review of the Far West Texas Project, and three of those four options included the Bakersfield – Solstice line. Additionally, ERCOT studied three primary options in its independent review of the Far West Texas Project 2, and each of those three options included the addition of a second 345 kV circuit to the Bakersfield – Solstice line.

Q. WHY WERE THOSE ALTERNATIVES REJECTED IN FAVOR OF THE BAKERSFIELD – SOLSTICE LINE?

A. In the Far West Texas Project independent review, ERCOT stated that it chose its recommended option because it met system reliability criteria for the studied load conditions, while deferring over $100 million in capital expenditures to await more certainty for greater load and generation resources in the areas. Compared to the rejected option that did not include construction of the Bakersfield – Solstice line, ERCOT's recommended option for the Far West Texas Project also allowed for multiple expansion paths to accommodate future, more certain load growth. As subsequently shown in the Far West Texas Project 2, that observation proved prescient.

The three primary options ERCOT evaluated in the Far West Texas Project 2 all included the addition of a second 345 kV circuit to the Bakersfield – Solstice 345 kV line along with several other universal transmission upgrades. These universal upgrades were included in all of the options to accommodate the planned Far West Texas Project 2 and allow for additional load growth on the Culberson Loop. Additionally, ERCOT determined that constructing two circuits on the Bakersfield – Solstice line from the outset makes economic sense compared to installing the second circuit at a later time due to reduced access, environmental and mobilization costs as well as construction efficiencies.

The options for connecting stations other than Bakersfield and Solstice with a 345 kV line were rejected because those alternatives would not provide an optimal location for a voltage source to address the identified criteria violations under the contingencies required to be studied. Other locations have inferior performance from an electrical standpoint because they do not provide enough of a network hub for multiple transmission circuits to benefit from the future 345 kV source.

Solstice is an ideal location for electrical connection because it is a major transmission hub in Pecos County. Between Solstice and the adjacent Barilla Junction station, there are terminations of eight different transmission circuits with connections to major switch stations for the region, including Pig Creek/Yucca Drive, Fort Stockton Switch, and Fort Stockton Plant. The transmission lines that exit Solstice serve the areas where load is growing and projected to continue growing, thus all customers served from these lines would benefit from the new 345 kV source.

Bakersfield is the strongest and main 345 kV source in the area. Weaker sources would not provide the appropriate voltage support to the underlying 138 kV system in the area where the reliability violations have been identified. There are no other feasible 345 kV facilities in the area, so Bakersfield is the best location to interconnect to the 345 kV transmission system for a strong voltage source. Bakersfield also has an existing 345 kV line to the Odessa EHV Switch, which when considered with future planned and recommended projects, will create a 345 kV transmission loop in the region. Creating the bi-directional looped service capability for the 345 kV system in the area is needed to address the reliability and operational flexibility for existing and future customers.

Q. WHAT ALTERNATIVES TO THE SAND LAKE – SOLSTICE LINE WERE STUDIED?

A. ERCOT studied three primary options in its independent review of the Far West Texas Project 2, and each of those three options included the Sand Lake – Solstice line.

Q. WHY WERE THOSE ALTERNATIVES REJECTED IN FAVOR OF THE SAND LAKE – SOLSTICE LINE?

A. As previously mentioned, the three primary options ERCOT evaluated in the Far West Texas Project 2 all included the Sand Lake – Solstice 345 kV line as a universal upgrade to accommodate the planned Far West Texas Project and allow for additional load growth on the Culberson Loop.

The options for connecting stations other than Sand Lake and Solstice with a 345 kV line were rejected because those alternatives would not provide an optimal location for the strong voltage source to address the identified criteria violations under the contingencies required to be studied. Other locations have inferior performance from an electrical standpoint because they are either farther from where the major load pocket along the Culberson Loop is, or do not provide enough of a network hub for multiple transmission circuits to benefit from the future 345 kV source. Thus connecting the 345 kV source to other locations would not adequately address all reliability criteria.

Sand Lake is an ideal location for an endpoint because it bisects the Culberson Loop in a geographic area where load is growing and projected to continue growing. Sand Lake also provides a network hub for future 345 kV injection because of the other approved or recommended projects being connected there, including the Riverton – Sand Lake 345/138 kV transmission line project previously approved in Commission Docket No. 47368 and the Riverton – Sand Lake 345 kV circuit upgrade endorsed by ERCOT as critical to reliability, which I previously discussed.

Solstice is an ideal location for electrical connection for the reasons I have previously discussed.

Q. WOULD DISTRIBUTION ALTERNATIVES TO THE PROPOSED TRANSMISSION LINE PROJECTS BE FEASIBLE?

A. No. Distribution alternatives to the Proposed Transmission Line Projects are not practical since they would not improve the reliability and operational capability of the transmission system in the area.

Q. WOULD VOLTAGE UPGRADES, CONDUCTOR BUNDLING, OR ADDITIONAL TRANSFORMERS PRESENT VIABLE ALTERNATIVES TO THE PROPOSED TRANSMISSION LINE PROJECTS?

A. No. New 345 kV sources, such as those offered by the Proposed Transmission Line Projects, are needed to upgrade voltage since all existing transmission facilities in the study areas were constructed and operate at 138 kV. The 138 kV facilities in the area currently serve customers directly and upgrading of voltage would require all customers and existing stations to be rebuilt in order to be served from 345 kV.

Conductor bundling would likewise not address the reliability and operational issues under the contingencies of concern since any bundled circuits would necessarily be located on the same structures as the existing 138 kV lines in the area. Additionally, bundling conductors does not provide bi-directional looped service capability which is needed to address the reliability and operational flexibility for existing and future customers.

Adding transformers would not address the reliability and operational issues under the contingency of concern since new 345/138 kV transformers within the Culberson Loop would still be served from the planned Odessa EHV – Riverton / Moss – Riverton 345 kV transmission line. With respect to the Bakersfield – Solstice 345 kV line, adding transformers would not address the reliability and operational issues under the contingency of concern because there is no existing or planned 345 kV source in the area, aside from the Bakersfield – Solstice line, from which to add a 345/138 kV transformer.

VI. CONCLUSION

Q. ARE THE PROPOSED FACILITIES NECESSARY FOR THE SERVICE, ACCOMMODATION, CONVENIENCE, OR SAFETY OF THE PUBLIC WITHIN THE MEANING OF PURA SECTION 37.056(A), TAKING INTO ACCOUNT THE FACTORS SET OUT IN PURA SECTION 37.056(C)?

A. Yes. Existing transmission service in the project area is inadequate, and the additional services provided by the Proposed Transmission Line Projects are critically needed to support the reliability and adequacy of the interconnected transmission system.

Q. PLEASE SUMMARIZE YOUR TESTIMONY.

A. The Proposed Transmission Line Projects are needed to address critical reliability issues resulting from rapid load growth in an area of oil and natural gas development and associated economic expansion. Specifically, the Proposed Transmission Line Projects will support load growth in the area, address reliability violations under ERCOT protocols and NERC reliability standards, and provide the infrastructure necessary to facilitate future transmission system expansion, all of which should improve service for new and existing customers. The Proposed Transmission Line Projects are the best solutions, compared to their respective alternatives, for addressing these issues while providing needed infrastructure to facilitate the long-term load-serving needs in these areas.

Q. DOES THIS CONCLUDE YOUR DIRECT TESTIMONY?

A. Yes, it does.

AFFIDAVIT

STATE OF TEXAS §
§
COUNTY OF DALLAS §

BEFORE ME, the undersigned authority, on this day personally appeared Brent R. Kawakami who, having been placed under oath by me, did depose as follows:

My name is Brent R. Kawakami. I am of legal age and a resident of the State of Texas. The foregoing testimony and exhibit offered by me are true and correct, and the opinions stated therein are, to the best of my knowledge and belief, accurate, true and correct.

Brent R. Kawakami

SUBSCRIBED AND SWORN TO BEFORE ME on this 2 day of November, 2018.

Notary Public, State of Texas

NISHA WAKEFIELD Notary ID# 124180849
NOTARY PUBLIC
STATE OF TEXAS
EXPIRES
JULY 2, 2022

My Commission Expires
7.7.2022

Brent Kawakami, P.E.
Oncor Electric Delivery Company LLC
2233B Mountain Creek Pkwy
Dallas, TX 75211
(214) 743-6686
brent.kawakami@oncor.com

Nov 2013-Present **Senior Engineer, Transmission Planning, Oncor Electric Delivery**
Identify and develop project plans to ensure transmission system reliability and provide service to generators, transmission service providers, and retail customers. Analyze, develop, and maintain electronic models of transmission system to evaluate performance under existing and future conditions.
- Responsible for the identification and initiation of transmission projects in West Texas service area.
- Led planning study and project development for 345 kV expansion in West Texas.
- Analyze load requests for large oil and gas customers and advise on high voltage service options.
- Calculate and maintain loading ratings for all autotransformers in Oncor transmission system.

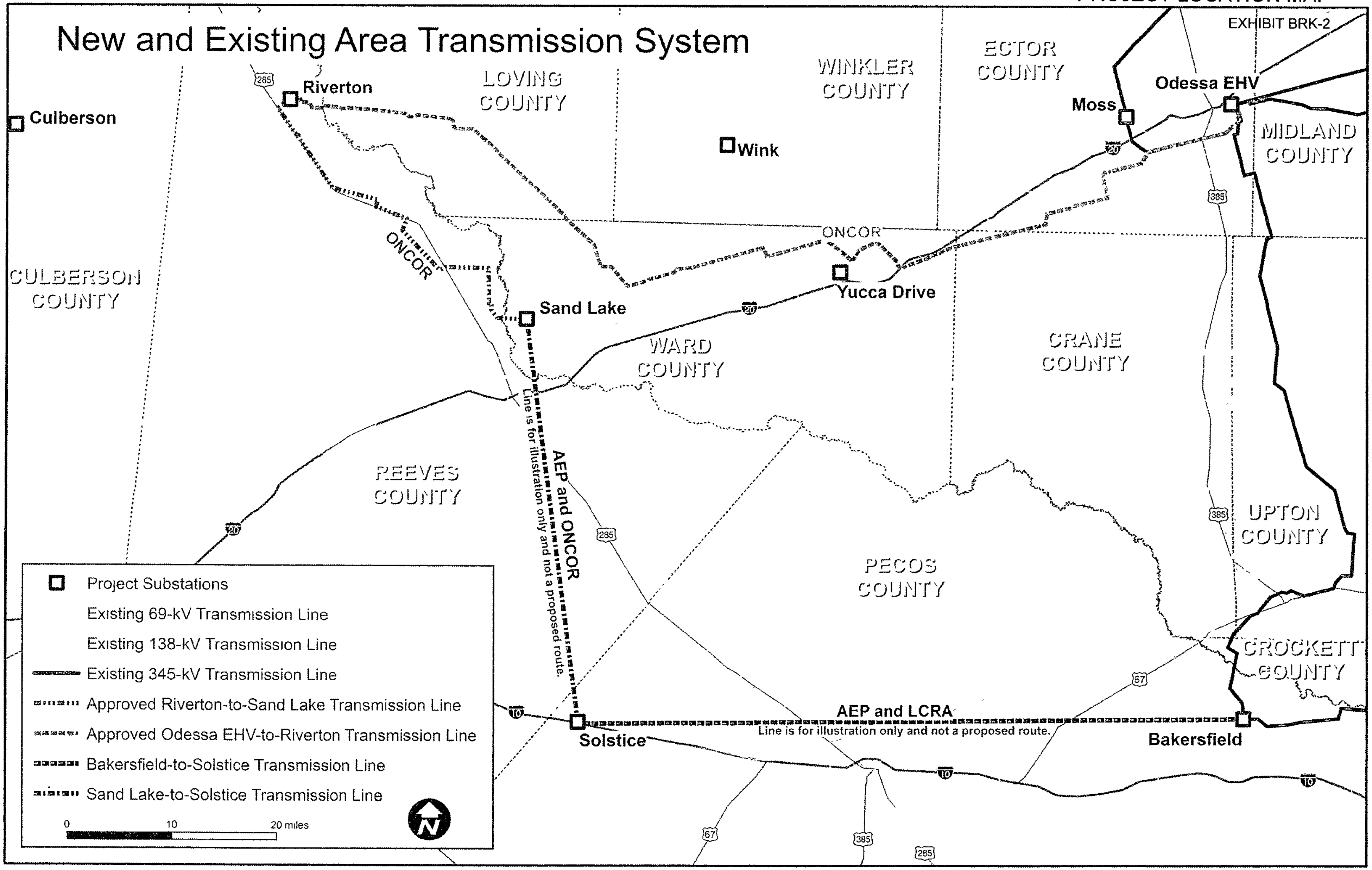
Mar 2011-Oct 2013 **Staff Engineer, Transmission Equipment Support, Oncor Electric Delivery**
Provided technical assistance to transmission operations field personnel. Led root cause investigations for substation equipment failures. Managed system wide equipment maintenance projects. Analyzed and evaluated substation equipment test data.
- Installed, tested, and advised on implementation of power transformer monitoring equipment.
- Calculated and monitored power transformer thermal levels during heavy loading conditions.
- Coordinated summer field inspections and maintenance programs for critical transmission facilities.
- Identified problem transformers and directed installation of mobile cooling or dehydrator units.

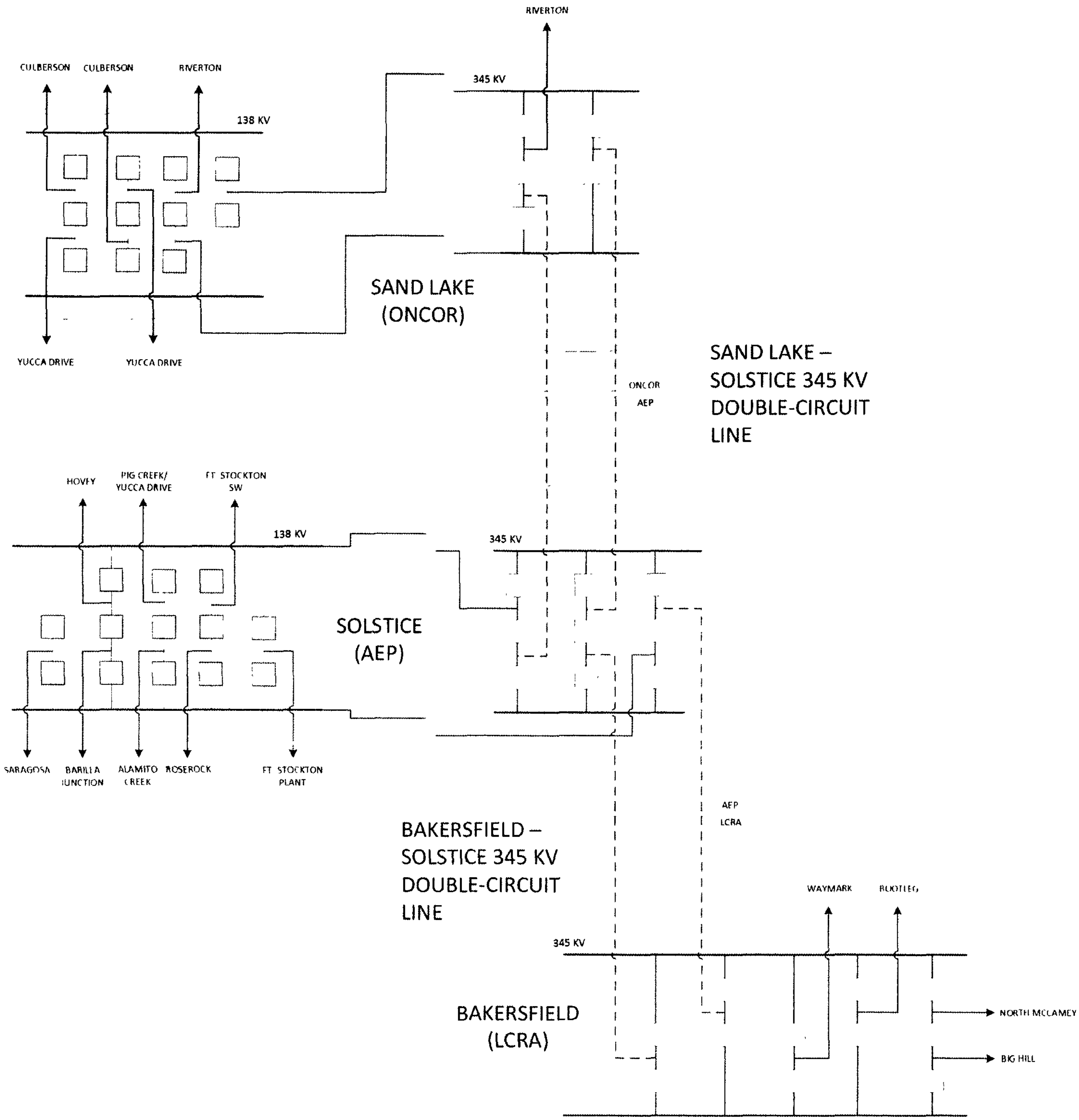
Feb 2009-Feb 2011 **Engineer, Transmission Engineering, Oncor Electric Delivery**
Responsible for the engineering design, material procurement, project management, and construction coordination in support of transmission substation projects. Produced engineering designs, drawings, equipment specifications, budgetary cost estimates, and bills of material to be used for construction.
- Managed and designed project for major substation expansion to serve new customer data center.
- Designed electrical scheme and specifications for brand new 138-25 kV distribution substation.
- Oversaw capital replacements of aging remote terminal units (RTU's) throughout Oncor system.
- Coordinated effort to reduce $250K of excess SCADA inventory.

B.S. Electrical Engineering, The University of Texas at Austin, 2008
Licensed Professional Engineer in the State of Texas (#116905)

PROJECT LOCATION MAP

EXHIBIT BRK-2




RIVERTON
CULBERSON
CULBERSON
RIVERTON
138 KV
345 KV
SAND LAKE (ONCOR)
YUCCA DRIVE
YUCCA DRIVE
SAND LAKE – SOLSTICE 345 KV DOUBLE-CIRCUIT LINE
ONCOR
AEP
HOVEY
PIG CREEK/ YUCCA DRIVE
FT STOCKTON SW
138 KV
345 KV
SOLSTICE (AEP)
SARAGOSA
BARILLA JUNCTION
ALAMITO CREEK
ROSEROCK
FT STOCKTON PLANT
AEP
LCRA
BAKERSFIELD – SOLSTICE 345 KV DOUBLE-CIRCUIT LINE
WAYMARK
BOOTLEG
345 KV
BAKERSFIELD (LCRA)
NORTH MCCAMEY
BIG HILL

FAR WEST TEXAS PROJECT

ERCOT REGIONAL PLANNING GROUP PROJECT SUBMITTAL FOR REVIEW

April 20, 2016

AMERICAN ELECTRIC POWER SERVICE CORPORATION
ONCOR ELECTRIC DELIVERY COMPANY CO LLC

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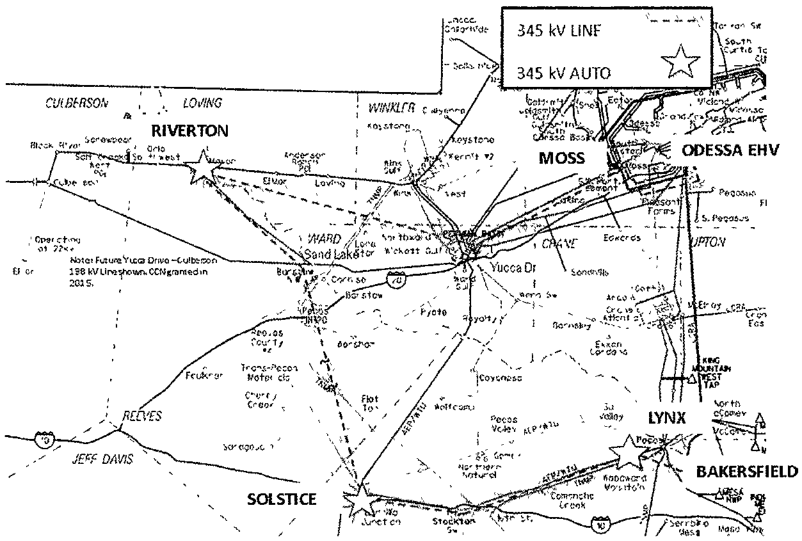
Executive Summary

This report describes the purpose and necessity to construct the Far West Texas Project (FWTP). The FWTP consists of a 345 kV line from Odessa to Moss to Permian Basin to Mason to Pecos to Barrilla to Fort Stockton to Rio Pecos to Bakersfield; with the initial installation of 345/138 kV autotransformers at Riverton, Solstice and Lynx stations. The estimated total cost of the project is $423 million with an in-service date of 2022 or sooner. It also provides for longer term growth in the Region by allowing for the future addition of a second 345 kV circuit and additional autotransformer installations. This is a joint project of American Electric Power Service Corporation (AEP) and Oncor Electric Delivery Co LLC (Oncor). We are requesting that ERCOT and the Regional Planning Group (RPG) consider and review this proposed project to address transmission constraints and needs.



AEP and Oncor continue to monitor West Texas load growth due to oil and natural gas production, transportation, mid-stream processing, and associated support activities in the Permian Basin. The Delaware Basin remains very active and significant load growth is resulting in the need for the addition of new transmission infrastructure in areas where little existed previously.

Additionally, AEP and Oncor continue to monitor new generation interconnection requests in the region. The Barrilla Junction Area southwest of Odessa remains very active with solar generation developments that will require additional transmission capacity and support.

The Far West Texas Project is needed to:

- Provide reliable service to current and future load
- Relieve planning criteria violations including overloading and voltage collapse with loss of load
- Support continuing oil/natural gas load growth and new generation interconnections
- Provide injection sources to aid short circuit strength limitations and meet system protection requirements
- Increase transmission operational flexibility under various normal and contingency conditions
- Provide a path for long-term upgrades to the region

AEP and Oncor are proposing and seeking endorsement of the FWTP which is proposed to be fully completed by 2021 to 2022. This date may change based on uncertainty in the timing of certification, environmental assessment, land acquisition, critical project status and/or other requirements.

Introduction

This report describes the need to construct the approximately 219-mile Far West Texas Project (FWTP) in Ector, Reeves, Pecos, Ward, and Winkler Counties.

The need to expand transmission facilities in West Texas is driven by increasing load due to the oil and natural gas industry and by solar generation development. Horizontal drilling technology has expanded production in the Permian Basin and resulted in increased electric demand to meet the requirements of oil and natural gas field operations, mid-stream processing, and a growing local economy. Much of this activity focuses on one of the largest reservoirs known as the Delaware Basin, and shown below in Figure 1.

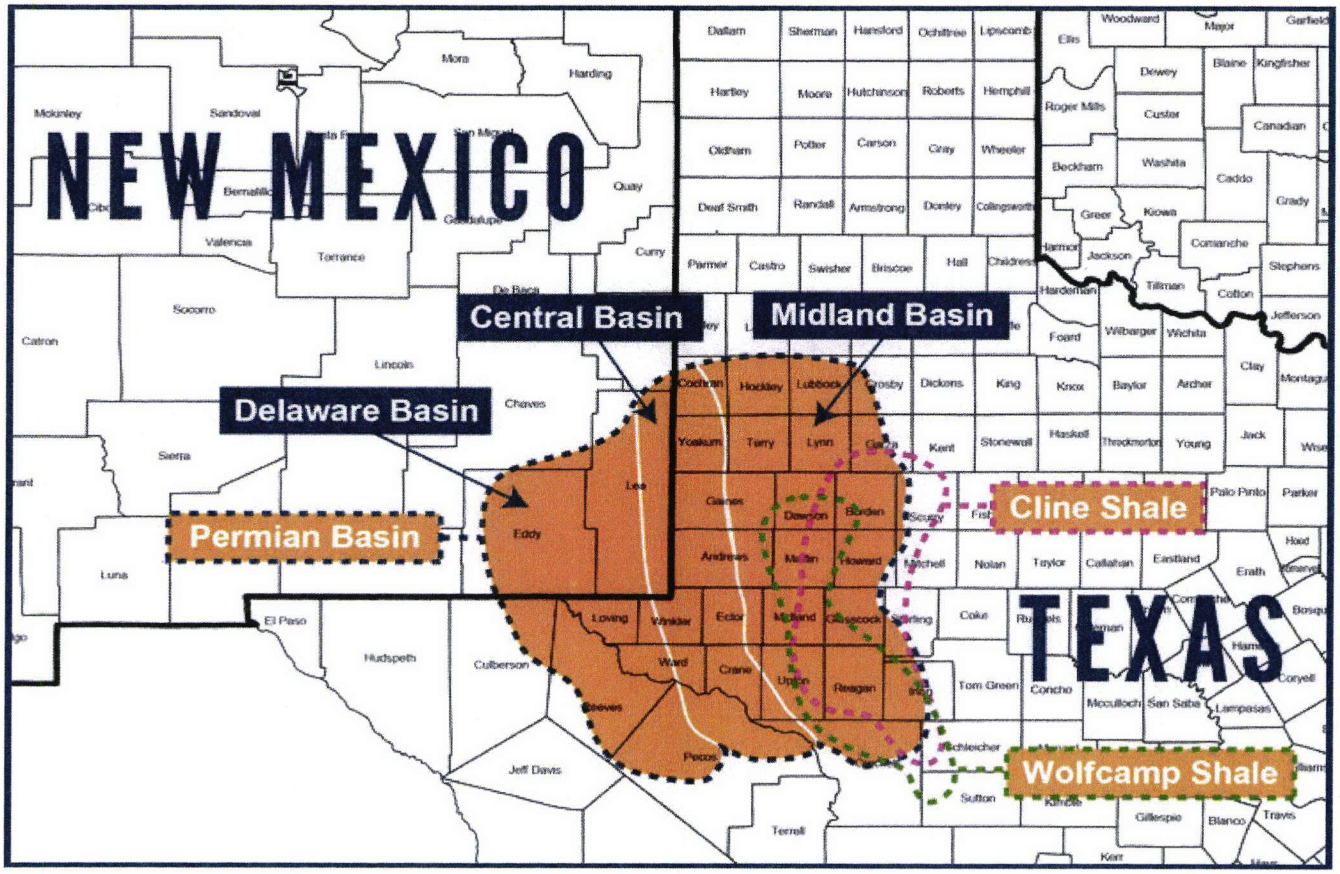


Figure 1 – Location of Delaware Basin

The loads in the Delaware Basin area are served by three Transmission Service Providers (TSPs) including Oncor, AEP, and Texas New Mexico Power (TNMP). All TSPs continue to support this growth with local area projects including the upgrade of existing transmission lines, installation of new and upgraded autotransformers, the conversion of the 69 kV system to a stronger 138 kV service, the installation of reactive devices, and the addition of substation capacity.

Oncor recently completed rebuilding the 138 kV line sections between Mason Substation and Screwbean Substation, which is part of a 74-mile radial line that extends from the Wink Switching Station (Sw. Sta.) to the Culberson 138 kV Sw. Sta. in Culberson County. The remaining 138 kV line section between Screwbean Substation and Culberson is planned for reconstruction by the end of 2017. Oncor will also begin construction on the new Yucca Drive – Culberson 138 kV Line in 2016. Yucca Drive is a new switching station near the Permian Basin Sw. Sta. located in Ward County. The new line will complete a 138 kV loop from Wink to Culberson and back to Yucca Drive (The Wink – Culberson – Yucca Drive Loop). In support of this Loop, Oncor recently submitted the new Riverton – Sand Lake 138 kV Line proposal to the ERCOT RPG.

AEP and Oncor also recently submitted the Barrilla Junction Area Improvement Project proposal to the ERCOT RPG, which includes rebuilding the Yucca Drive – Barrilla Junction 138 kV Line. The area southwest of Odessa, served by the 69 kV and 138 kV lines between Permian Basin, Barrilla Junction, Fort Stockton Plant, and Rio Pecos stations (The Barrilla Junction Area) has seen an increased interest in solar generation development.

While these previously submitted projects are effective in addressing local issues, they provide limited improvement on a larger scale and do not provide a new transmission source, a 345 kV source, to satisfy the growing load and the interconnection needs of new generation in the Far West Texas area. Both the previously submitted 138 kV projects and the FWTP needed as part of the long-term plan in West Texas .

The location of the FWTP and surrounding transmission system is shown below in Figure 2. The respective areas of The Wink – Culberson – Yucca Drive Loop and The Barrilla Junction Area are shown within the blue circles.

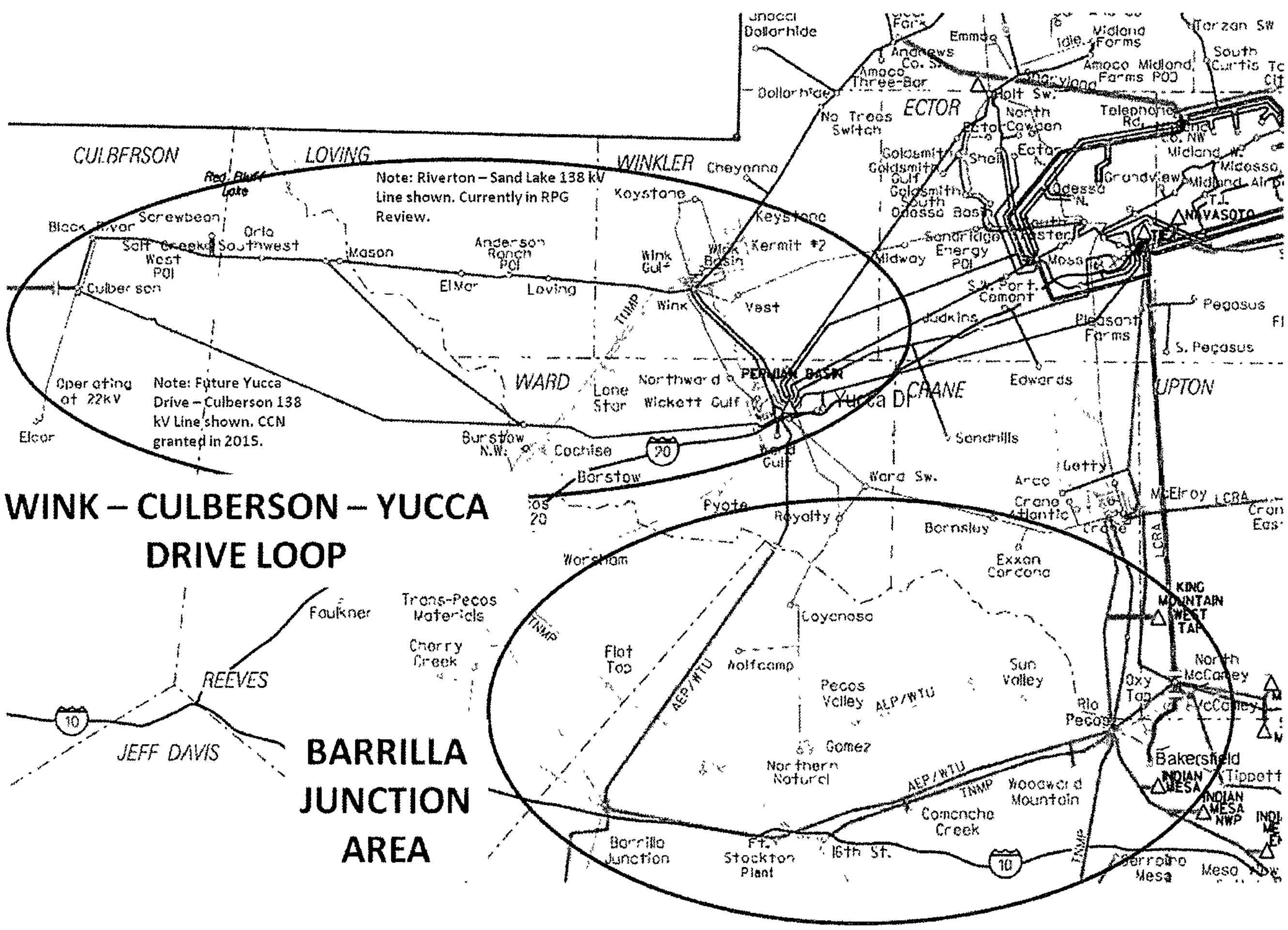


Figure 2 – Location of the Far West Texas Project

Purpose and Necessity

Load Growth

The electric load in West Texas has grown dramatically over the last several years. This load growth is continuing due to the oil/natural gas industry and supporting businesses. Recent improvements in oil and natural gas horizontal drilling technologies have increased activity in the area, resulting in major load growth at existing substations and the need for new substations to serve the added load in Far West Texas. Despite declining oil prices over the last 18-24 months, AEP and Oncor have continued to experience increased loads in this area compared to historical load levels. This increase in oil and natural gas production, transportation and mid-stream processing has resulted in economic growth in the area that is supporting the industry. Figure 3 below shows the growing load in the area despite a production drawback in the Permian Basin.

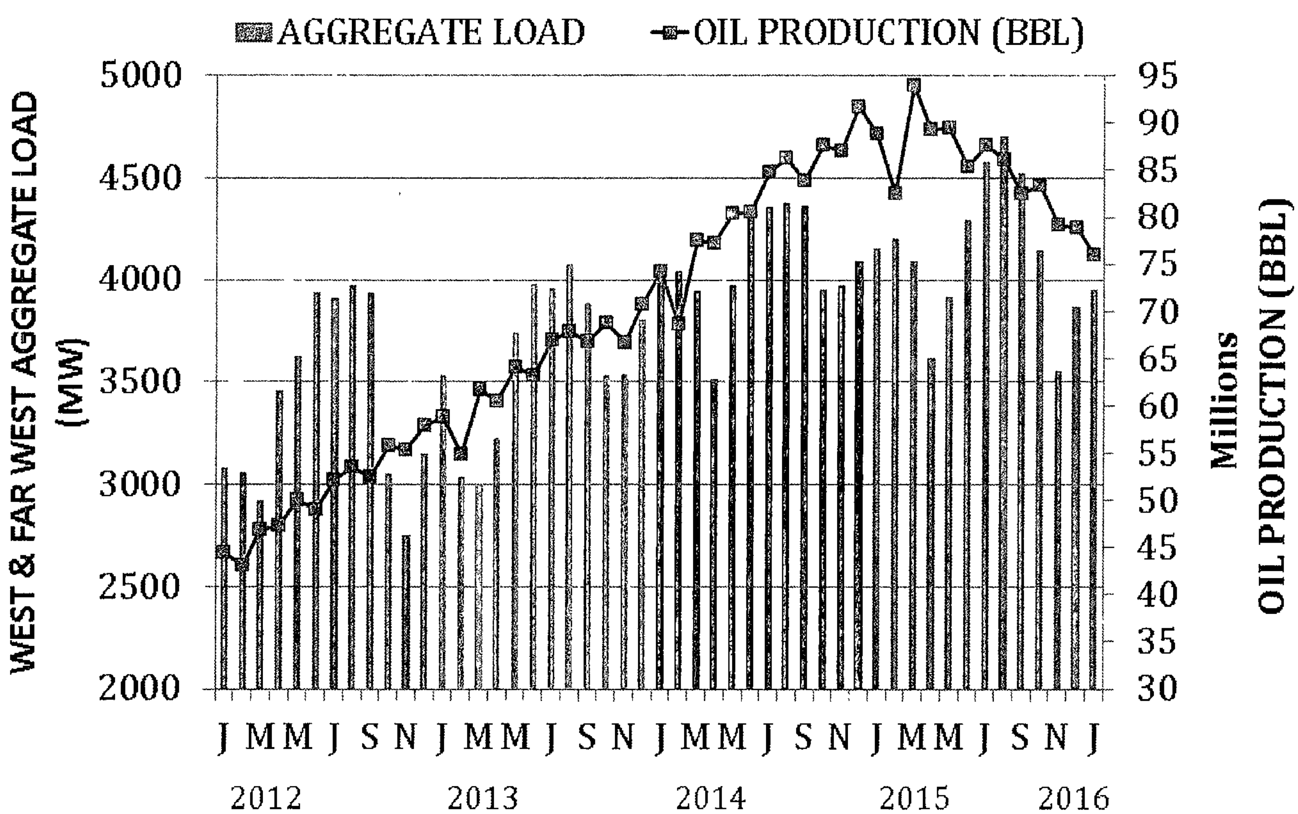


Figure 3 – Growing Aggregate Load vs. Oil Production

While the oil and natural gas production levels have recently leveled, the business friendly environment of Texas, existing infrastructure, and the geological characteristics of the Permian Basin make it a prime candidate to be the first oil and natural gas area that returns to high growth levels. Additionally, developing improvements in horizontal drilling technologies are resulting in improvements in efficiencies, speed, and service cost reductions which will only improve horizontal well margins and economics as time progresses. More background info and data is available from the link below for the "Oil and Gas Seminar – An Education on the Permian Basin Production and Processing Techniques" held November 10, 2015 at ERCOT in Austin, TX.
http://www.ercot.com/calendar/2015/11/10/76898-WORKSHOPS

Secondary facilities that follow and support production, including midstream processing plants, also create a challenge for area TSPs as they are large amounts or "blocks" of load, sometimes 40 to 100 MW located 50 to 100 miles apart. The inherent nature of midstream facilities results in wide variations in electrical power needs and geography, allowing for little predictability or transparency into exact locations for these developments, other than being regionally located with production fields. The need for transmission facilities to adequately serve these types of midstream facilities is critical since such large loads can have large, stressing impacts on transmission system capacity and voltage.

The FWTP is located in the Delaware Basin, a highly active area for drilling for oil and natural gas in the western portion of the Permian Basin. The electrical summer peak load for Oncor counties within the Delaware Basin, including Culberson, Reeves, Loving, Ward and Winkler Counties grew at an annual rate of approximately 13% from 2012 to 2015. Oncor's expected annual growth for the area will average 11% over the next five years and 7.0% over the next 10 years.

The table below shows the sum of historical and projected summer peak loads (MW) for The Wink – Culberson – Yucca Drive Loop. The loads from 2010 to 2015 are actual summer peaks (MW), and the loads for 2016 to 2021 are projected summer peaks (MW) from the 2016 Annual Load Data Request (ALDR). These projections only include confirmed load increases from normal load forecasting and signed customer agreements. There are other active inquiries to connect additional customers in the area, but the load associated with these requests has not been included in Table 1.

	Historical Load						Projected Load					
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total (MW)	22.4	21.6	33.4	53.2	89.7	105.4	231	304	343	391	411	426

Table 1- Historical and Projected Load (MW) Served from the Wink – Culberson – Yucca Drive Loop

Currently AEP projects over 350 MW of summer peak load for The Barrilla Junction Area. With the oil and natural gas activity in the area, AEP anticipates that The Barrilla Junction Area load will grow to over 500 MW by 2021 with over 160 MW being served by the Yucca Drive – Barrilla Junction 138 kV Line alone. Table 2 below shows the sum of projected summer peak loads (MW) being served by the Barrilla Junction Area transmission lines.

	2016	2017	2018	2019	2020	2021
Total (MW)	387	454	483	487	490	511

Table 2- Projected Load (MW) Served from the Barrilla Junction Area Lines

Oncor studies have shown that as load increases in the Delaware Basin on The Wink – Culberson – Yucca Drive Loop, additional projects will be needed to adequately serve the load. AEP studies have shown that after the Barrilla Improvement Transmission Project, additional thermal issues will exist on the two 138 kV paths between Barrilla Junction/Solstice and Rio Pecos. Additional transmission infrastructure improvements will be needed to reliably serve growing load in the region.

Generation Growth

The Barrilla Junction Area is under increased interest for solar generation development. As of April 2016, more than 7,700 MW of solar development projects are currently in the ERCOT generation interconnection process, most of which are concentrated in the West and Far West weather zones of West Texas where transmission infrastructure is either relatively weak or no infrastructure exists.

Currently there is over 1,650 MW of renewable generation in The Barrilla Junction Area including a 160 MW wind facility (Woodward Mountain) that is interconnected west of Rio Pecos. There is approximately 850 MW of conventional generation north of the Barrilla Junction Area at Permian Basin SES, Odessa Ector, and Quail. Figure 4 below shows The Barrilla Junction Area and surrounding generation.

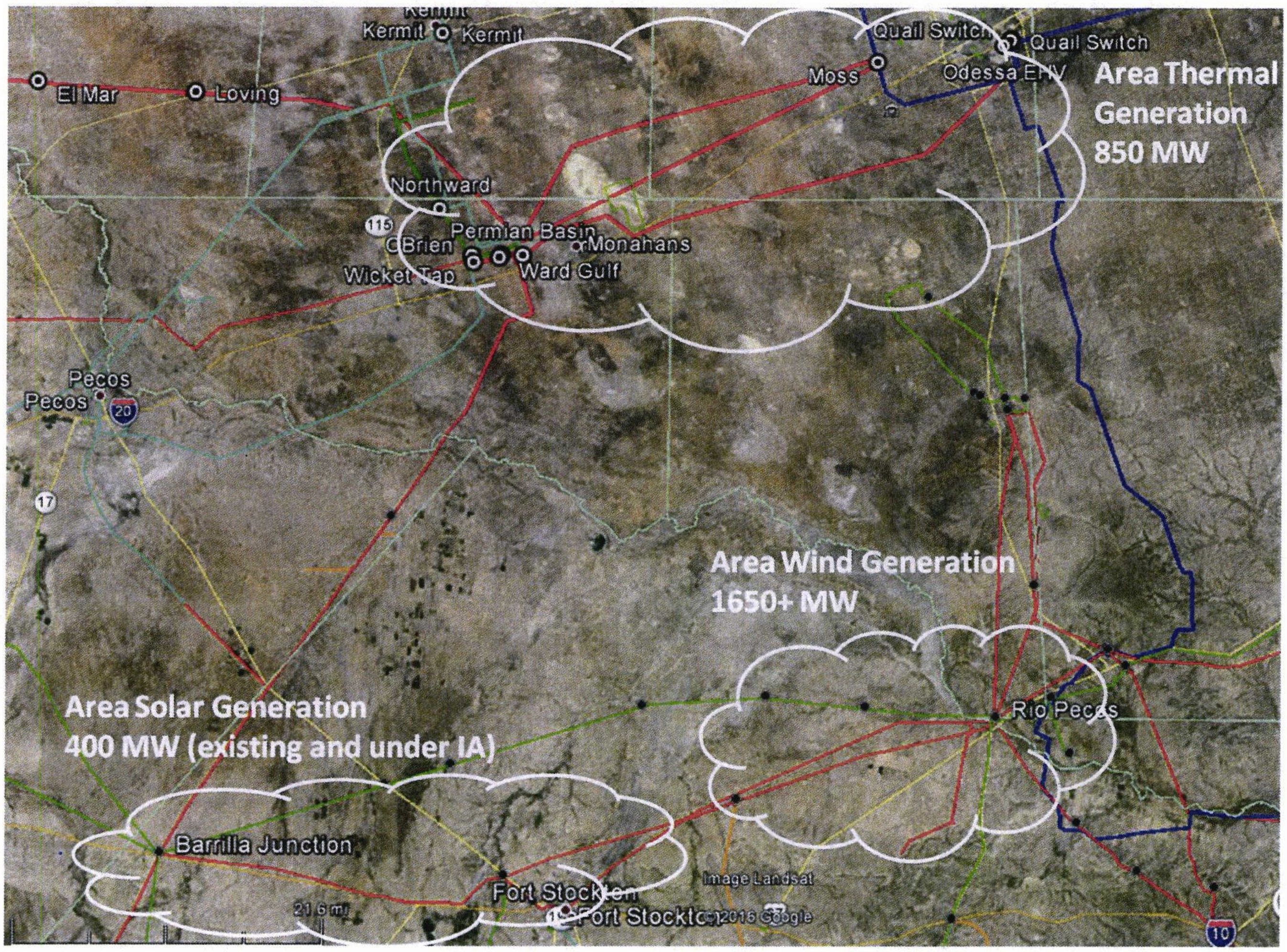


Figure 4- Barrilla Junction Area and Surrounding Generation

Both AEP and Oncor have received multiple inquiries for generation interconnects in the region. Based on the March 2016 ERCOT Transmission Generation Interconnect Project list, there are 27 projects in the planned status in the FWTP's surrounding counties of Culberson, Pecos, Reeves, and Winkler counties totaling 3,380 MW of new generation. New solar generation developments account for 25 of the 27 projects.

Oncor has 5 requests in the study queue for generation interconnects in the FWTP's surrounding area, totaling 758 MW of new generation. New solar generators represent 4 of the 5 requests, totaling 635 MW.

AEP has approximately 1,000 MW in signed interconnect agreements (IAs) with solar generators that are connecting in Pecos, Reeves, and Upton counties with approximately 400 MW connecting directly on the 138 kV and 69 kV transmission system in the Barrilla Junction Area. In addition, AEP has an additional 1,000 MWs of generation in the study queue.

The solar generation facilities in The Barrilla Junction Area include:

- Barrilla Solar (50 MW) located just west of the existing Barrilla Junction 138 kV Station
- Rose Rock (150 MW) that has an executed IA and is under construction which will interconnect at the Barrilla Junction/Solstice Station
- Oak Solar (150 MW) that has an executed IA and will be connected to the Fort Stockton Plant 138 kV Station
- Solaire Holman (50 MW) that has an executed IA and will be connected to the Ft. Stockton Plant – Alpine 69 kV Line
- East Pecos Solar (120 MW) that has an executed IA and will be connected at Bakersfield 345 kV Station
- Maplewood Solar (500 MW) that has an executed IA and will be connected at Bakersfield 345 kV Station

AEP studies indicate that the transmission lines in The Barrilla Junction Area will be close to their maximum transfer capability with the interconnection of these future solar generation facilities. As a result, transmission infrastructure improvements will be needed in the region to support future solar development. With Federal Investment Tax Credits extended, solar and other renewable generation developments in the area are expected to continue.

The Far West Texas Project satisfies existing and anticipated reliability needs, creates new pathways for new generation to access the 345 kV transmission system, increases transfer capacity, and enables reliable transfer to load centers. Completion of the FWTP also provides greater flexibility in conventional generation dispatch, which should help address congestion in the area.

Oncor Studies

Oncor studies identified certain outages on The Wink – Culberson – Yucca Drive Loop that result in unacceptable system conditions. The worst contingency in this region is loss of the Wink – Loving 138 kV line section, which causes the remaining line sections looking toward Culberson and Yucca Drive to be insufficient to maintain adequate system operating conditions, resulting in an unsolved contingency during power flow analysis. The unsolved contingency shows an inability of the power system to maintain stable bus voltages following a disturbance or deviation from its initial operating condition. These unacceptable voltage conditions in the area will increase as load on The Wink – Culberson – Yucca Drive Loop rises to even higher levels.

Upon seeing these issues, Oncor began development and completion of several projects in the area. In addition to completing the rebuild of the existing Wink – Culberson 138 kV Line, Oncor has plans to install a shunt capacitor at Castile Hills and install second circuits on both the Wink – Culberson and the new Yucca Drive – Culberson 138 kV lines. In addition to installing double-circuits on The Wink – Culberson – Yucca Drive Loop, Oncor will relocate some substations onto the new second circuits in order to help voltage regulation and further diversify line loading. Support is also provided by the addition of the Riverton – Sand Lake 138 kV Line currently under review by the ERCOT RPG.

While these projects would initially help support system voltages pre- and post-contingency, additional voltage support will be needed in the area as the load continues to grow. Dynamic stability studies indicate additional improvements are needed in the area in order to support system voltage levels and increase system strength.

Below in Figure 5, the worst single-circuit branch outage voltage plot is shown with all the previously mentioned projects in place. The Wink – Culberson – Yucca Drive Loop voltage response is able to stabilize to acceptable levels, however delayed voltage recovery is evident, which could cause problems for customer load, particularly those of oil and natural gas customers. The simulation assumed heavy motor load, typical of oil and natural gas load in the area, using a 2019 base case.

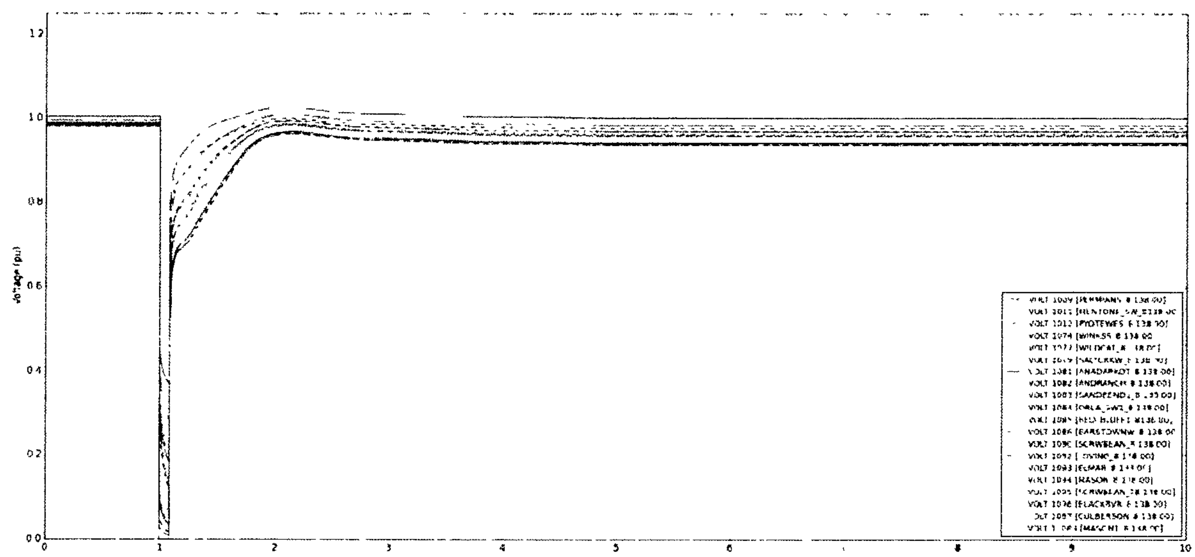


Figure 5 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for Worst Single-Circuit Branch Outage

The majority of the loads on these lines serves oil and gas customers who employ voltage sensitive electric equipment in their operations. For example, many customers are using electric submersible pumps (ESP) as the artificial lift technology for wells. This type of load operates continuously (24 hours/day, 7 days/week) under normal conditions and maintains a high load factor.

With certain double-circuit branch outages, The Wink – Culberson – Yucca Drive Loop is unable to recover to normal levels, which does not meet the ERCOT voltage recovery criteria in the Planning Guide. Figure 6 below shows voltage response under this scenario with the same base case assumptions.

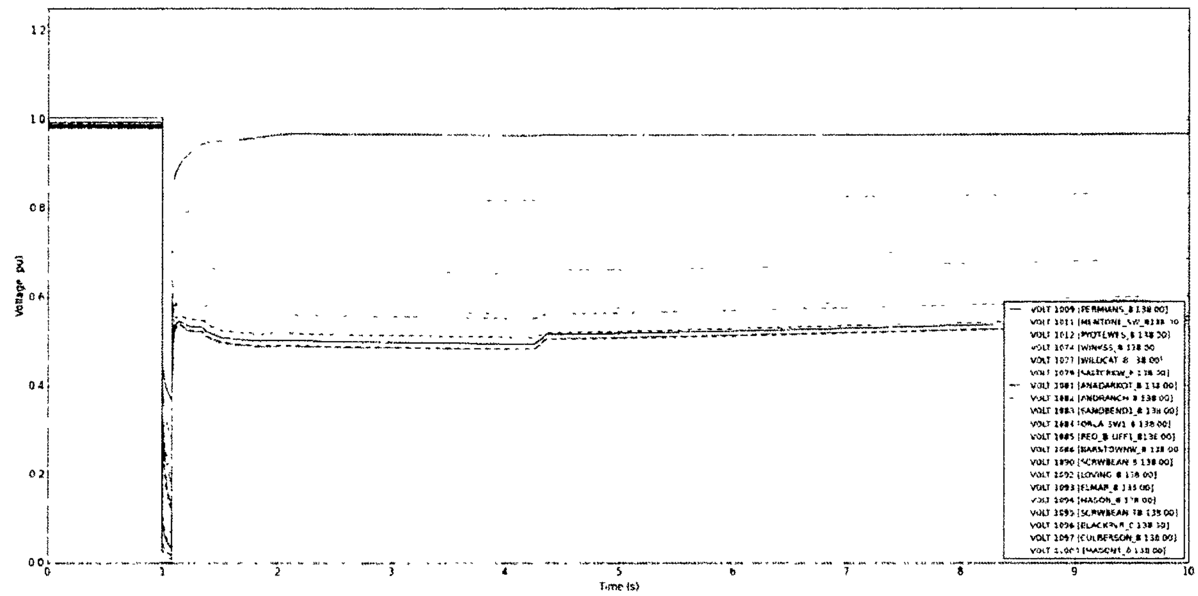


Figure 6 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for Worst Double-Circuit Branch Outage

Certain contingencies beyond NERC requirements can result in consequential load loss or result in a radial 138 kV transmission line exceeding 100 miles in length. Although these contingencies are beyond base planning requirements, the severe consequences merit consideration. The resulting transmission system is skeletal and fragile making discrete switched shunt reactive support not practical because power angles become excessive, and local voltage collapse with loss of load can occur. Figure 7 below shows the simulated dynamic voltage response of The Wink – Culberson – Yucca Drive Loop for one such scenario.

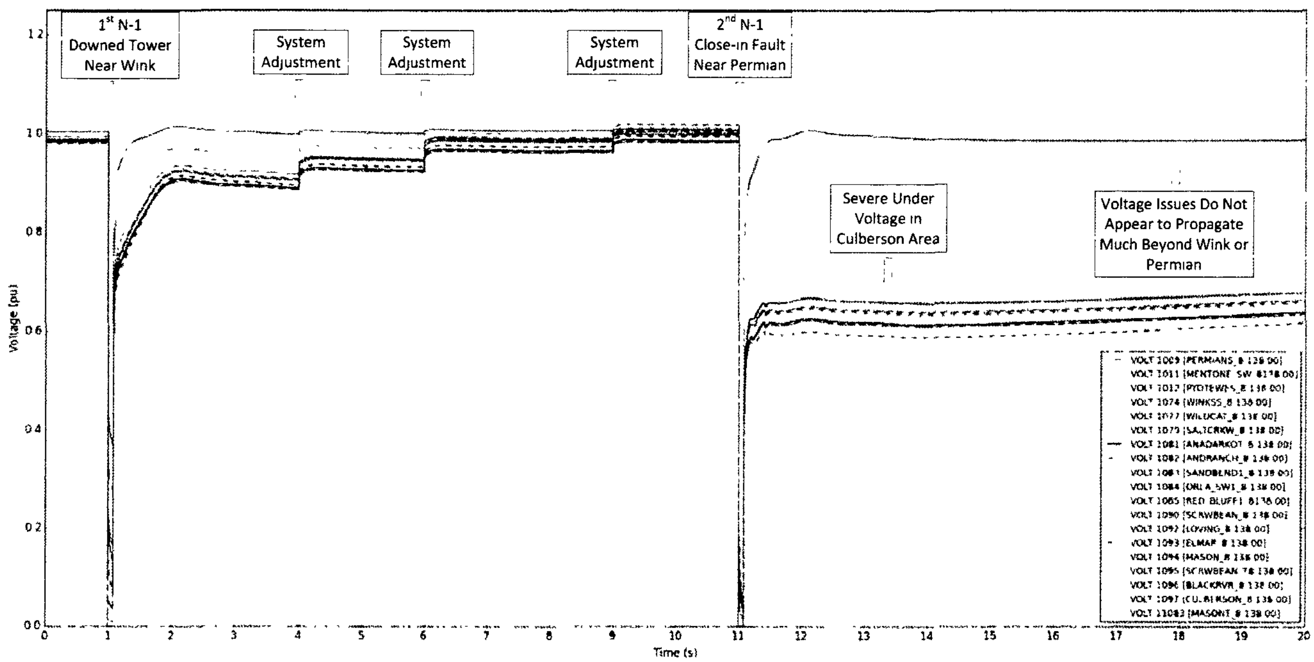


Figure 7 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Light Motor Load)

It should be noted that while this simulation is above normal minimum study requirements, it is in line with clearance requests and has significant consequences including load loss exceeding 300 MW. Additionally, the simulation plot above was performed assuming light motor load. If heavy motor load is assumed the dynamic stability simulation fails to converge after the second fault. In fact for The Wink – Culberson – Yucca Drive Loop, heavy motor load may be a more reasonable assumption given the amount of oil and natural gas related customers served from this line. In that scenario, after the system is adjusted, the next contingency results in a local voltage collapse and loss of load that cannot be mitigated by normal operator action. The voltages at Permian Basin and Wink however do stabilize, showing the condition does not propagate to the rest of the system.

The FWTP will strengthen system voltage and provide a strong 345 kV source into The Wink – Culberson – Yucca Drive Loop. This will address the voltage collapse concerns described previously and provide a resilient long-term solution for increasing system strength in the area. Figure 8 and Figure 9 below show the same dynamic simulation with the FWTP modeled. Figure 8 shows the voltage response assuming light motor loading and Figure 9 shows the voltage response assuming heaving motor load. In both cases, the voltage collapse conditions after the worst N-1-1 contingencies are completely mitigated by the 345 kV loop.

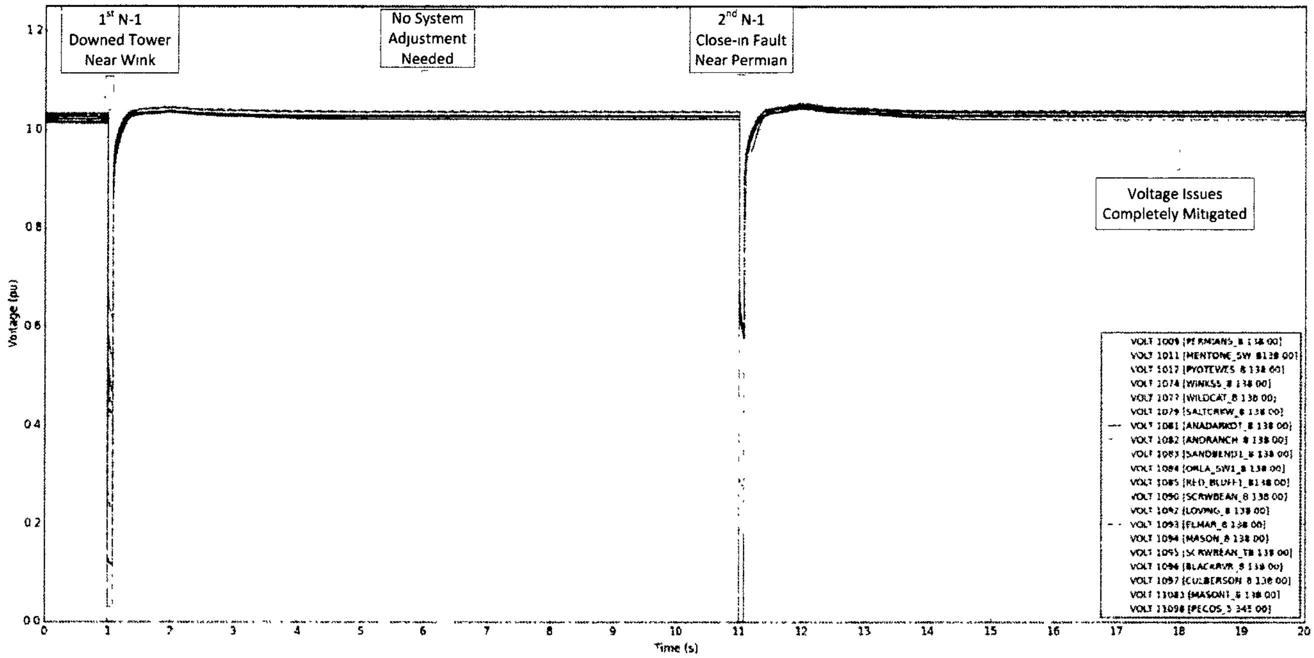


Figure 8 – Dynamic Voltage Response of Wink - Culberson – Yucca Drive Loop for N-1-1 contingency (Light Motor Load) – FWTP

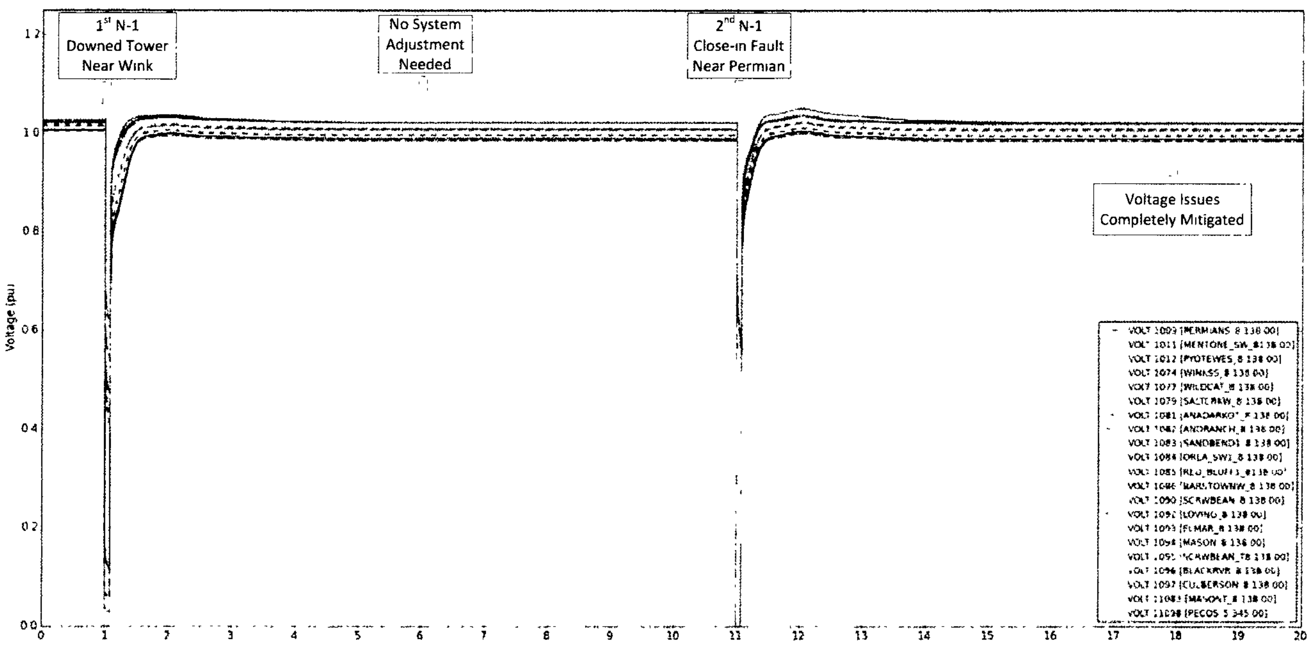


Figure 9 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Heavy Motor Load) – FWTP

ERCOT Studies

ERCOT identified similar planning criteria violations to the Oncor studies in its 2015 Regional Transmission Plan (RTP) and its preliminary 2015 West Texas Study (WTS) results.

The 2015 ERCOT RTP shows similar results to the Oncor studies in the Culberson loop area, with the RTP cases becoming unsolvable under the P1 contingency loss of any one of several single segment circuits on The Wink – Culberson – Yucca Drive Loop. Using the 2015 ERCOT RTP 2018 Summer case posted by ERCOT on April 14, 2015, the same unsolved case conditions can be seen after loss of the Wink – Wildcat 138 kV line section. Using either the 2015 ERCOT RTP 2020 or the 2021 cases, the same unsolved case conditions result after the loss of either the Loving – Anderson Ranch or the Wink – Wildcat 138 kV line sections.

As a result, the need for this project was identified in the 2015 RTP as reliability project 2015 RTP-FW3. A portion of the FWTP for a new 345 kV line to the area from Odessa EHV and Moss was identified as a potential project solution. Currently ERCOT is working on the 2016 RTP and has indicated to Oncor that the preliminary results are showing similar issues in the area.

Similarly, the same conditions were seen in the preliminary results provided to Oncor for the 2015 ERCOT WTS. Using the 2015 ERCOT WTS 2017 Summer Case posted by ERCOT on May 15, 2015, loss of the Wink – Loving 138 kV line section results in The Wink – Culberson – Yucca Drive Loop unable to maintain adequate voltage limits and results in the same unsolved case conditions seen by Oncor studies. The ERCOT WTS 2019 and 2020 cases show similar results under the same contingencies.

AEP Studies

As part of the Barrilla Junction Area Improvement Project RPG submission, AEP performed numerous steady-state studies assessing the integrity of the transmission system in The Barrilla Junction Area. In these studies, AEP identified additional thermal and voltage violations beyond the direct interconnection facilities of the Barrilla Junction to Yucca Drive 138 kV Line that exceed thermal ratings. These include the 138 kV and 69 kV transmission lines heading south from Barrilla Junction towards the Marfa and Ft. Davis Area, as well as the 138 kV and 69 kV transmission lines heading east from Barrilla Junction/Solstice towards Ft. Stockton Plant and Rio Pecos.

In order to determine the most appropriate system conditions to model for evaluating the reliability of the study area, several scenarios were considered. Combinations of wind, gas and solar generation dispatch were adjusted, simulated, and results compared. Each of the adjusted system conditions used to determine the final scenarios analyzed for the study are detailed in the sections below.

AEP utilized the summer peak power flow cases with High Solar/Low Wind/High Gas (HS/LW/HG), High Solar/High Wind/Low Gas (HS/HW/LG), Low Solar/Low Wind/Low Gas (LS/LW/LG) and Low Solar/Low Wind/High Gas (LS/LW/HG) dispatches.

- In the Low Wind (LW) dispatch, all the area wind generators were dispatched at 20% with the exception of the two Woodward units that were dispatched to 0%.
- In the High Wind (HW) dispatch, all area wind generators including the Woodward units were dispatched at 100% of Pmax.
- In the Low Solar (LS) dispatch, all the solar generators in the study area were dispatched to 0%.
- In the High Solar (HS) dispatch, all solar generators in the study area were dispatched at 100% of Pmax.

- In the Low Gas (LG) dispatch, all the area gas generators were dispatched at 20% with the exception of the Permian Basin gas units that were dispatched at 0%.
- In the High Gas (HG) dispatch, all the area gas generators were dispatched at 100% of Pmax.

The dispatch assumptions associated with the HS/LW/HG, HS/HW/LG, LS/LW/LG and LS/LW/HG scenarios are shown below in Table 3.

	2020 HS/LW/HG	2020 HS/HW/LG	2020 LS/LW/LG	2020 LS/LW/HG
Solar	100%	100%	0%	0%
Wind	20%	100%	20%	20%
Woodward	20%	100%	0%	0%
Gas	100%	20%	100%	100%
Permian	100%	20%	0%	100%

Table 3 – AEP Barrilla Junction Area Study Dispatch Assumptions

As mentioned in the Barrilla Junction Area Improvement Project RPG submittal, AEP studies revealed a number of remaining thermal issues on the two 138 kV transmission paths out of Rio Pecos after the Barrilla Junction Area Improvement Project is implemented. The resulting line loading in The Barrilla Junction Area is shown below in Table 4.

Branch	Rate C (MVA)	Study Case LW/LS/LG %Loading	Study Case HW/HS/LG %Loading	Study Case LW/HS/HG %Loading
Rio Pecos – Woodward Tap 138 kV	170	124	20	18
Rio Pecos – TNMP Woodward Tap 138kV	154	131	113	70
Ft. Stockton Plant 138/69 kV auto transformer	68.8	116	123	67
Ft. Stockton – Tombstone 138 kV	170	99	38	23
Ft. Stockton Plant – TNMP Airport 138 kV	158	106	38	21
Ft. Stockton Plant – Barrilla Jct/Solstice 138 kV	170	124	106	65
Woodward Tap – Tombstone 138 kV	170	124	48	28
Ft. Stockton – Barrilla Junction 69 kV	38	116	127	58
TNMP 16th Street – TNMP Woodward Tap 138 kV	154	131	59	18
TNMP 16th Street – TNMP Airport 138 kV	158	113	44	14

Table 4 – AEP Barrilla Junction Area Study Line Loading

AEP studies show certain scenarios where the amount of generation able to be exported from the Barrilla Junction Area would be limited because of thermal constraints on the transmission system. With the large amount of generation coming online and significant constraints due to the limited exit paths out of the Barrilla Junction Area, generators in the area would likely see curtailments until additional transmission improvements were made in the region.

Additionally, further stability studies have identified voltage stability concerns in the McCamey 138 kV transmission system as a result of the additional generation interconnections at or near the Bakersfield Sw. Sta. The studies identified certain scenarios where a N-1-1 contingency would limit the amount of generation that can be exported due to voltage stability concerns.

The FWTP will provide an additional export path for generation that would otherwise flow into the McCamey 138 kV system, addressing export limitations due to potential voltage instability. Additionally, the project would create a looped exit path for the approximately 2.2 GW of potential new generation coming online in the Far West Texas transmission system.

Short Circuit Strength

Short circuit strength in the FWTP's area is also a concern. In the FWTP's area, there are several long lines with significant load that could become radial under P1 contingencies. If a radial line is both long and heavily loaded, it can become difficult for relays to distinguish between fault and load current. Furthermore, low short circuit strength can cause issues for customers, such as inability to start large motors.

Low short circuit strength in an area can cause difficulty in properly protecting the transmission system. Transmission line relays must protect for faults anywhere along the line, even during clearance/outage scenarios. If fault currents in an area are generally low, the outage of a nearby source can significantly reduce the availability of relay settings that reliably trip for any fault condition, while simultaneously avoiding trips for any non-fault condition. Additionally, relay coordination with breakers in surrounding areas may become problematic.

For example, during certain outages in The Wink – Culberson – Yucca Drive Loop, a fault at the remote end of the radial section may result in fault currents as low as 860 Amperes, which is equivalent to 205 MVA of load at nominal voltage. Under these conditions, the maximum load that could be reliably served on this circuit must be below 205 MVA since some margin is required to provide secure protection. This amount is not near the capacity of the line (2,569 Amperes or 614 MVA) and does not meet criteria for system protection requirements. With the FWTP in place, simulations indicate that fault current may increase to 3,300 Amperes for the same scenarios, which is equivalent to 788 MVA of load, exceeding the conductor rating and providing sufficient margin for secure protection.

Figure 10 (next page) shows a color contour map representing the relative short circuit strength in the north part of FWTP's area. The regions colored in red, such as The Wink – Culberson – Yucca Drive Loop in the upper left corner of the diagram, indicate areas with very low short circuit strength. Much of the area is relatively weak, particularly when compared to areas closer to Odessa EHV and conventional generation, shown in the regions in blue. The simulations represented in the maps show the scenario with conventional generation in the FWTP's Area in-service. The situation becomes more dismal if generation in the area is out-of-service as indicated.

The addition of a strong source, such as the injection of a new 345 kV source, into the FWTP's area aids in increasing short circuit strength and stability, particularly when nearby conventional generation is not in-service.

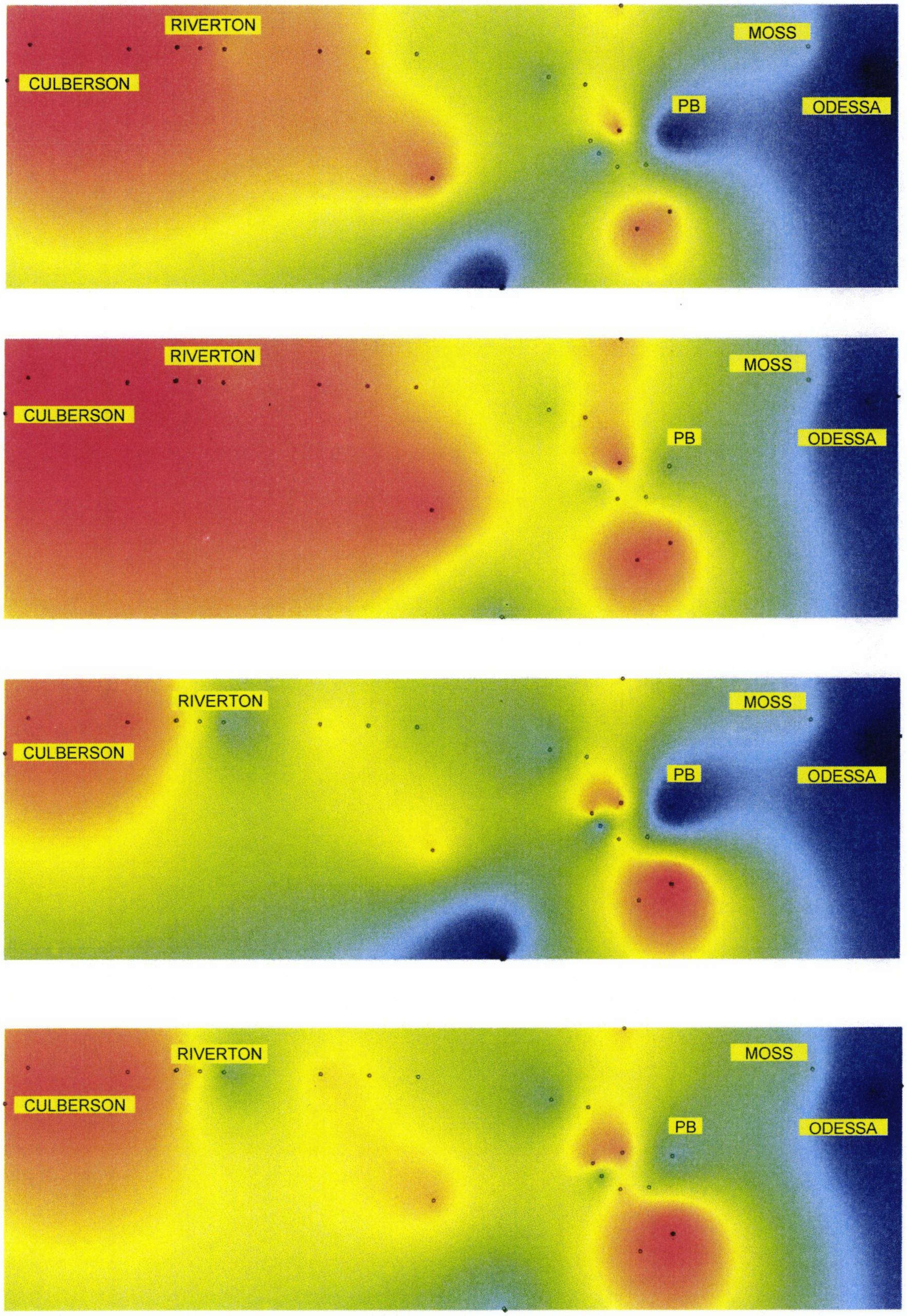


Figure 10 – Relative Short Circuit Strength Color Contour Maps – FWTP

High Voltage Points-of-Delivery (PODs)

AEP and Oncor continue to receive multiple inquiries from oil and natural gas producers for future high voltage (HV) interconnections along the transmission lines in the Delaware Basin area. In The Wink – Culberson – Yucca Drive Loop, customers with existing HV points-of-delivery (PODs) in the area have projected increases in load. Not included in the projections shown previously in Table 1 are four requests for new customer-owned substations totaling 45 MW. One potential customer has indicated future development plans in the Delaware Basin near the FWTP area that includes electrical requirements that could reach as high as 180 MW total.

The FWTP will help to serve additional load growth by providing extra high-voltage transmission service closer to existing and future customers in the Delaware Basin, where HV PODs can be established. Extending the 345 kV system into these regions of the Delaware Basin will increase system strength and provide voltage support in an area where customers frequently experience low voltage problems and strict motor start limitations.

TSP Point-of-Interconnections

Challenges in West Texas with regards to rapid changes in generation interconnections, customer service requests, system protection, engineering, constructability, operability, outage/clearances and maintainability have encouraged West Texas TSPs to expand on joint coordination efforts for planning future area needs. As the area continues to see generation and load additions, joint coordination will be needed to ensure a strong and reliable transmission system.

AEP and Oncor have performed joint planning to determine optimal solutions that would benefit all parties. As mentioned previously, AEP and Oncor have immediate needs to rebuild the Yucca Drive – Barrilla Junction 138 kV Line via the Barrilla Junction Area Improvement Project, however these 138 kV upgrades do not resolve all thermal issues on the existing 138 kV lines between Barrilla Junction/Solstice and Rio Pecos. Additionally, Oncor has needs to address the reliability issues in The Wink – Culberson – Yucca Drive Loop.

Texas New Mexico Power (TNMP) has also engaged AEP and Oncor in joint planning discussions in Ward, Winkler, and Reeves counties. TNMP has indicated expected load increases on their transmission system due to large HV customers and sees the need for additional upgrades due to potential thermal and voltage issues post-contingency. TNMP's system in this area is comprised solely of a 69 kV network with radial circuits branching off at multiple points and relies on transmission sources from Oncor's Wink and Permian Basin stations. TNMP has indicated desires for future HV points-of-interconnection with AEP and Oncor in the area, and would greatly benefit from the strong injection source that 345 kV provides.

The FWTP will address planning criteria violations and operational issues for AEP, Oncor and TNMP. Additionally a looped 345 kV line in the area will create additional transmission infrastructure for future points-of-interconnection between other TSPs. Implementation of a 345 kV source provides for a resilient system that all TSPs in the area can benefit from and provides for the beginning of a 345 kV loop around the area, that can be expanded to provide additional lines to the north or east as future needs dictate.

Operational Flexibility

The lack of operational flexibility when transmission facilities are taken out of service during construction and maintenance is an increasing problem in West Texas. Due to increasing load levels and uncertain availability of wind and other generation in the area, the ability to take facilities out of service for scheduled clearances, maintenance, or testing is limited by voltage and thermal constraints caused by the next contingency. This often leads to congestion and/or unavailability of clearances.

Numerous elements in the FWTP's area are noted as High Impact Transmission Elements (HITEs) by the ERCOT Outage Coordination Improvements Task Force (OCITF). These are transmission elements where outages have contributed to significant congestion and transmission constraints in recent history. Notable elements include the Moss Switch 138 kV Bus, Odessa EHV 138 kV Bus, Midland East – Odessa EHV 345 kV Line, Midland East – Moss 345 kV Line, Moss – Odessa EHV 345 kV Line, and the Odessa EHV 345/138 kV autotransformer #3. With many constraining 345 kV elements in the local area, expansion of the 345 kV system will help strengthen the area to enable clearances and withstand unplanned outages with fewer congestion concerns.

The FWTP will help strengthen the system voltage and increase the operational flexibility in West Texas, allowing utilities to upgrade facilities, perform scheduled maintenance and perform testing of their facilities.

Region Long Term Upgrade Path

In addition to providing the best technical solution to support planning standard requirements and maintain a reliable system today, the need to optimize improvements to adequately meet future needs must be considered. With limited amounts of transmission infrastructure in areas of far West Texas, new project options to address reliability issues in a fast changing landscape can be limited.

AEP's and Oncor's long range planning analysis considered needs in The Wink – Culberson – Yucca Drive Loop, The Barrilla Junction Area, and Far West Texas in general for future voltage support, transfer capacity, and load serving transformers. Future long-term projects that have been identified include:

- Add 345/138 kV, 600 MVA autotransformer at Sand Lake Sw. Sta.
- Add 345/138 kV, 600 MVA autotransformer at Wolf Sw. Sta.
- Add 345/138 KV, 600 MVA autotransformer at Fort Stockton Plant Sw. Sta.
- Add second 345/138 kV, 600 MVA autotransformer at Moss Sw. Sta.

The Far West Texas Project will have built-in upgrade paths to accommodate future growth needs in the region. This will provide flexibility for future project additions depending on timing of future load or generation increases. Based on increasing load and future interconnections with other TSP's in The Wink – Culberson – Yucca Drive Loop, the Sand Lake 345/138 kV autotransformer can be quickly installed to meet required needs.

In addition to locations where an autotransformer can be installed relatively quickly, a second 345 kV circuit can be installed to provide additional transfer capacity in The Wink – Culberson – Yucca Drive Loop and The Barrilla Junction Area. These upgrades will ensure the proposed solution is a resilient option that can meet future long range needs in Far West Texas.

Project Description

AEP and Oncor will coordinate respective portions of the project to support design, construction, and other activities. The estimated in-service date is 2021 to 2022. This date may change based on uncertainty in the timing of certification, environmental assessment, land acquisition, critical project status and/or other requirements. Below are individual descriptions of the pieces of this project:

Odessa EHV – Riverton 345 kV Line (Oncor)

Add a second circuit to the existing 16-mile Moss Sw. Sta. – Odessa EHV 345 kV double-circuit structures. Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Sw. Sta. Install 345 kV circuit breaker(s) at Odessa EHV. Connect the new circuit from Riverton Sw. Sta. and terminate at Odessa EHV to create the new Odessa EHV – Moss – Wolf – Riverton 345 kV Line.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new rights-of-way (ROW). The new line should be routed near the future Wolf Sw. Sta. near Permian Basin SES to provide for future facility additions. Oncor is requesting "critical" designation for this line to quickly mitigate the voltage collapse and load loss issue described previously.

Riverton Switching Station (Oncor)

Expand the Riverton Sw. Sta. to install a 345 kV ring-bus arrangement with one 600 MVA, 345/138 kV autotransformer. Install two 37.5 Mvar (75 Mvar total) shunt reactors on the tertiary of the autotransformer.

Solstice 345 kV Switching Station (AEP)

Expand the Solstice Sw. Sta. to install a 345 kV ring-bus arrangement with one 675 MVA, 345/138 kV autotransformer.

Riverton – Solstice 345 kV Line (AEP & Oncor)

Construct a new approximately 66-mile 345 kV line on double-circuit structures with one circuit in place from Riverton Sw. Sta to Solstice Sw. Sta. Oncor will build half the line from Sand Lake and AEP will build half the line from Solstice.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new ROW. The new line should be routed near the future Sand Lake Sw. Sta. for future facilities additions.

Lynx 345 kV Switching Station (AEP)

Expand the Lynx Sw. Sta. to install a 345 kV ring-bus arrangement with one 675 MVA, 345/138 kV autotransformer.

Solstice – Lynx 345 kV Line (AEP)

Construct a new approximately 59-mile 345 kV line from Solstice Sw. Sta. to Lynx Sw. Sta. on double-circuit structures with one circuit in place. The new line should be routed near Fort Stockton Plant for future facilities additions.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new ROW.

Lynx - Bakersfield 345 kV Line (AEP)

Construct a new approximately 9-mile 345 kV line from Bakersfield station to the Lynx Sw. Sta. on double-circuit structures with one circuit in place.

This portion of the project will require the completion of an environmental assessment, alternative route analyses, certification (CCN) proceedings, and the acquisition of new ROW.

Project Costs

The total cost of these improvements is estimated at $423 million. The approximate station and line works costs for AEP and Oncor are shown below.

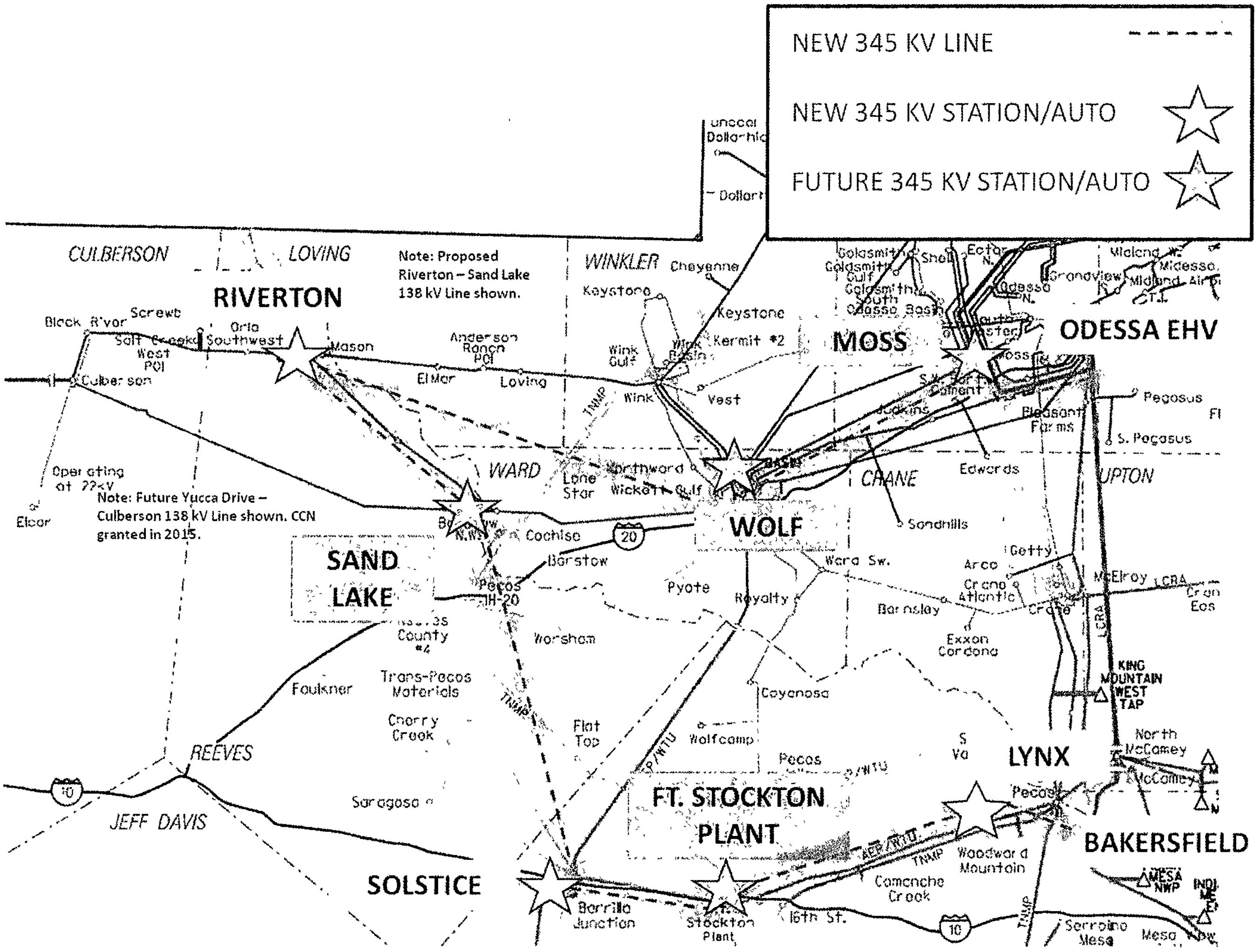
AEP

- Station: $43 million
- Line: $146 million

Oncor

- Station: $17 million
- Line: $217 million

Figure 11 below shows a depiction of the Far West Texas Project overlay using blue highlighting.



One-line Diagram

Figure 12 below shows a one-line diagram of the area, where the Far West Texas Project components are dashed.

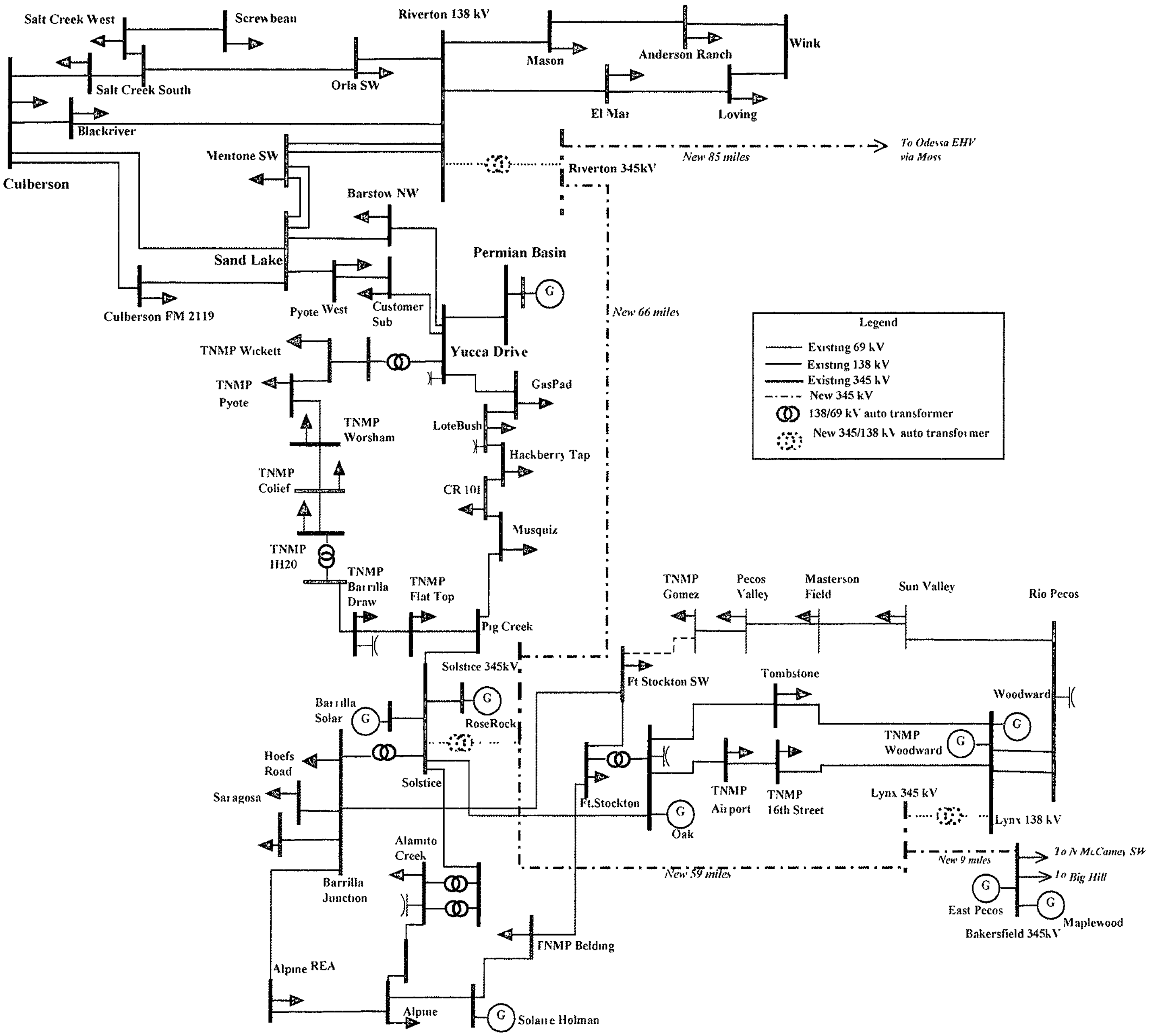


Figure 12- Far West Texas Project One-Line Diagram

Alternative Projects

Both AEP and Oncor considered various options to resolve the identified reliability issues and provide adequate transmission infrastructure to connect new solar generation and oil and natural gas load. Alternatives to the Far West Texas Project are various combinations of existing 69 kV rebuilds, 138 kV rebuilds, and numerous large dynamic reactive devices. While these alternative projects would address local thermal or voltage issues with varying levels of performance depending on local area generation dispatch and load projections, they have limited improvement on a the larger scale for providing a strong transmission source and a resilient solution to increasing system strength in the area.

Providing single radial 345 kV injection points in the Far West Texas Project's area was considered and would greatly improve system strength, reliability, and address planning criteria violations. However the first contingency loss of any new radial 345 kV line or single 345/138 kV autotransformer would negate the benefit of the single 345 kV source. For example, under certain N-1-1 events, whether through planned or unplanned outages, the same planning criteria issues and subsequent voltage collapse risks in The Wink – Culberson – Yucca Drive Loop would remain. As load increases in the region the ability to take these facilities out for maintenance, testing, or construction clearances will become increasingly difficult. The most effective solution is a 345 kV loop around the area that can be established to provide bi-directional capability of the new 345 kV source.

Alternative - Dynamic Reactive Device(s), 138 kV, and 69 kV Upgrades

In order to adequately address the short-term criteria violations found by AEP and Oncor, a combination of many 138 kV and 69 kV rebuilds in addition to new dynamic reactive devices, will be needed. These projects are estimated to cost $480 million and higher.

With no 345 kV source into The Wink – Culberson – Yucca Drive Loop area of the Delaware Basin, Oncor studies indicate that 138 kV network expansion, in combination with large dynamic reactive devices, will be required to support future load growth by helping to provide voltage regulation and enabling adequate power transfer under reasonable operating scenarios.

Oncor dynamic studies have determined that a large synchronous condenser (300 Mvar minimum) would be needed in order to address the previously described issues in The Wink – Culberson – Yucca Drive Loop. The studies show that a Static VAR Compensator (SVC) or a Static Synchronous Compensator (STATCOM) would not converge for a number of simulations, indicating an insufficiency for mitigating the voltage collapse risks.

Figure 13 below shows a comparison of the voltage responses after the worst N-1-1 contingency in The Wink – Culberson – Yucca Drive Loop with a 300 Mvar synchronous condenser modeled at Riverton Sw. Sta. In the simulation, heavy motor load was assumed.

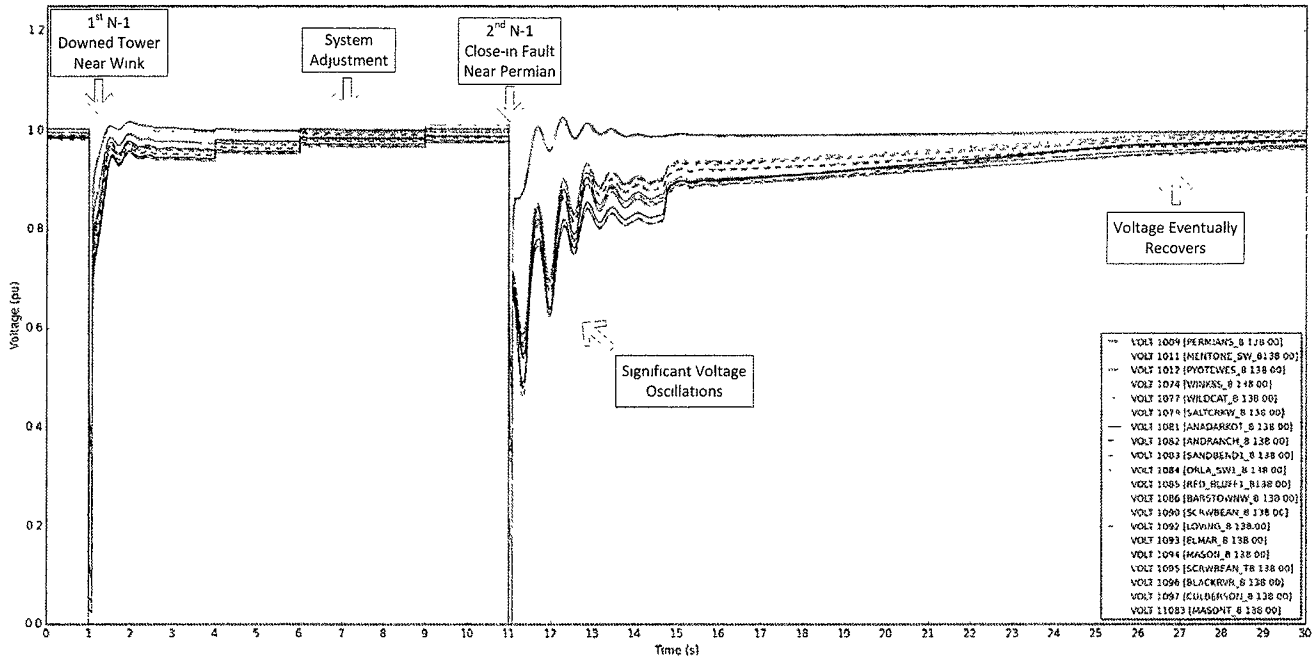


Figure 13 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Heavy Motor Load) – 300 Mvar Synchronous Condenser

It should be noted that while the voltage in The Wink – Culberson – Yucca Drive Loop eventually recovers to normal operating levels, there are significant voltage oscillations upon recovery. With potential swings of more than 0.2 PU, electrical equipment including those of customers mentioned previously in this report could be at risk. The required device would likely need to be larger, such as 400 Mvar. Figure 14 below shows the same simulation with a 400 Mvar synchronous condenser modeled.

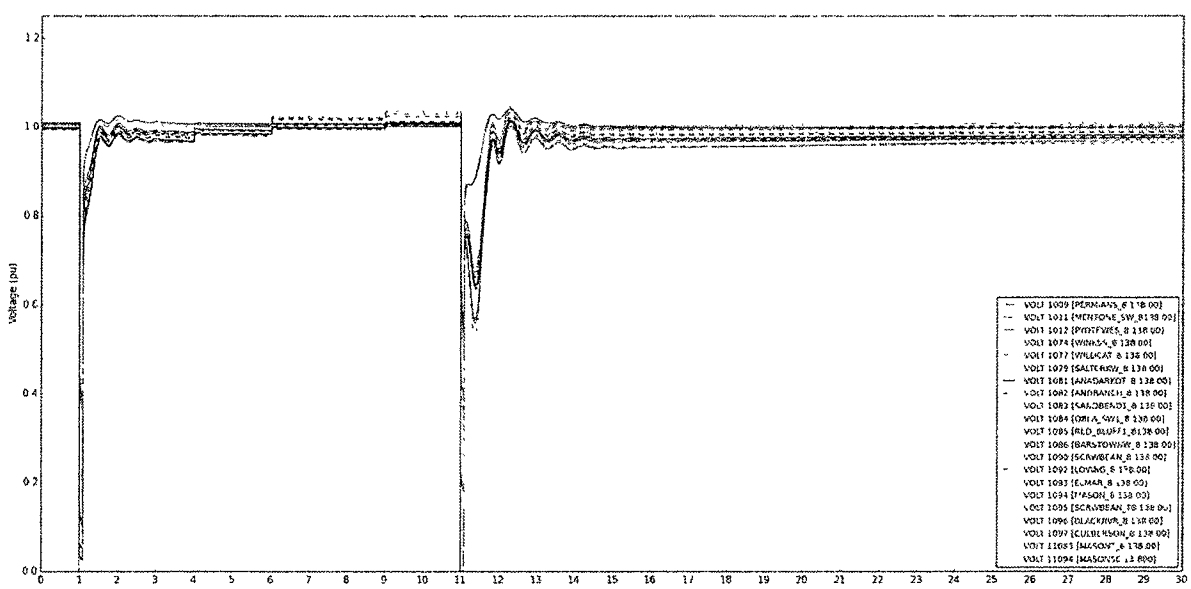


Figure 14– Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency (Heavy Motor Load) – 400 Mvar Synchronous Condenser

Placing such a large, complex device in an extremely remote area also has significant operational and maintenance concerns. The area near Riverton Sw. Sta. is extremely remote, and with limited road access and no nearby population, such a facility would be away from field personnel responding to any planned or unplanned outage, maintenance, or testing. Re-occurring inspections and maintenance will be required which must also be considered in the evaluation of installing such a device. The on-going service costs are not included in the alternative estimate. Additionally, the large size required for a 400 Mvar device will be cumbersome through construction, maintenance, and testing. Two synchronous condensers would be required for redundancy under contingency loss of the first device.

While this alternative addresses the initial planning criteria concerns, this option does not increase system strength and does not provide any strong injection points to the 138 kV system. Additionally, there is no clear upgrade path with these 138 kV and 69 kV alternatives. Future 138 kV projects including new circuits and additional dynamic reactive devices will likely be required as load increases on The Wink – Culberson – Yucca Drive Loop, adding to the future costs of the alternative.

Oncor studies show that if load growth goes beyond current projections in the area, the synchronous condenser would experience angular instability and the simulation solutions would diverge. Figure 15 below shows the voltage response under the worst N-1-1 contingency, if load growth on The Wink – Culberson – Yucca Drive Loop increased above current projections.

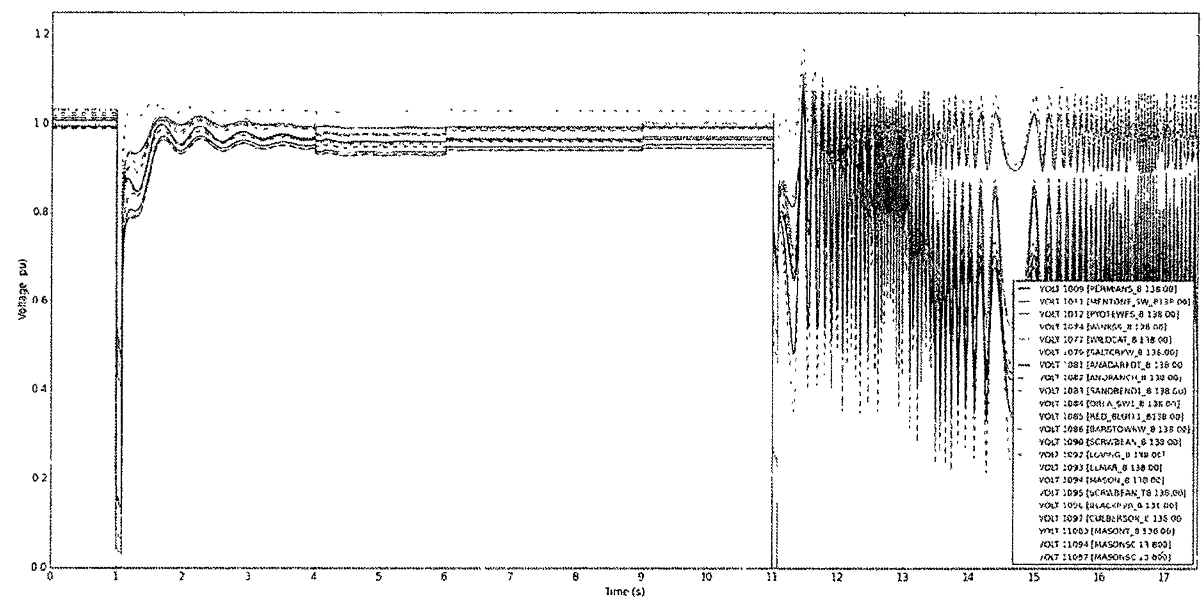


Figure 15 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency – Synchronous Condenser

With the FWTP in place, The Wink – Culberson – Yucca Drive Loop could still withstand an increase above current load projections. Figure 16 below shows the FWTP under these conditions with the same N-1-1 contingency. This means that the FWTP will not only resolve the current issues of voltage collapse and load loss, but will also provide ample transmission capacity for load growth well into the future.

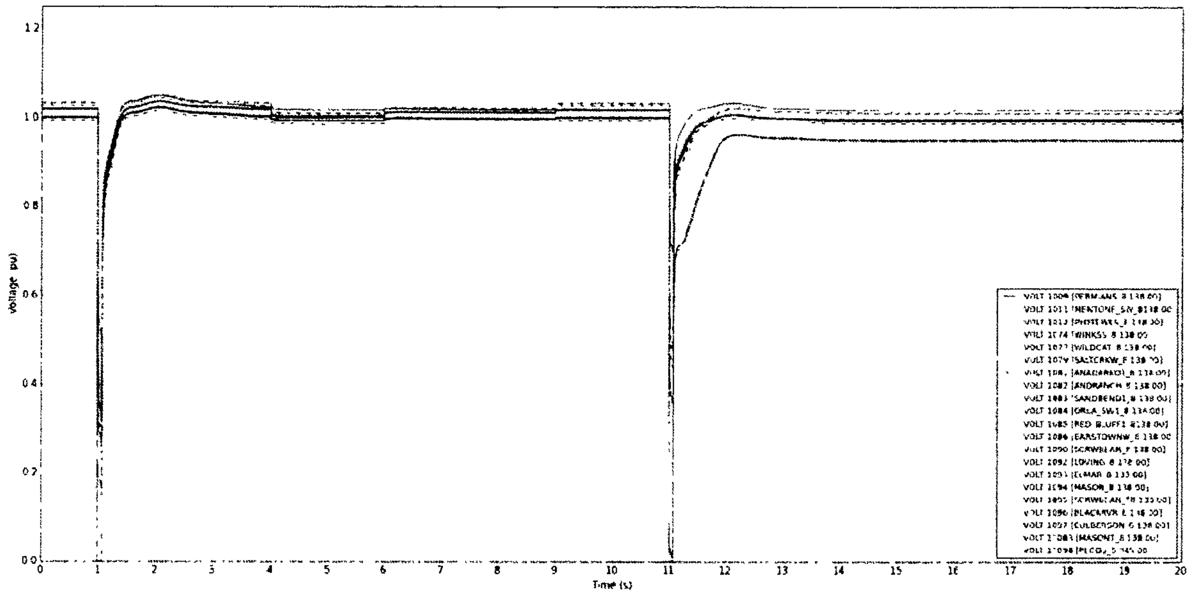


Figure 16 – Dynamic Voltage Response of Wink – Culberson – Yucca Drive Loop for N-1-1 contingency – Far West Texas Project

With no 345 kV source into The Barrilla Junction Area, AEP studies show that the remaining 69 kV and 138 kV lines in the Barrilla Junction Area that have not been addressed by the Barrilla Junction Area Improvement Project would need to be rebuilt. This equates to more than 170 miles of existing 69 kV and 138 kV transmission lines.

While rebuilding the existing corridor of transmission lines in The Barrilla Junction Area would address the thermal overloading concerns, this alternative does not provide a new transmission path into The Barrilla Junction Area for any new solar generation in the region to interconnect. Additional new source paths may be needed in the area to accommodate growth beyond what has been studied. AEP studies have also shown the 345 kV option to perform better under the same contingency and dispatch scenarios as this alternative and provides for additional transfers on the existing Ft. Stockton Plant – Rio Pecos paths.

Conclusion

The joint decision by AEP and Oncor to construct the Far West Texas Project will provide a backbone 345 kV infrastructure to support load growth, support voltage, improve system protection issues and provide pathways for new generation interconnects in the region southwest of Odessa. The Far West Texas Project will help support transmission voltage in the Delaware Basin area both pre- and post-contingency by providing a strong source into an area that is primarily served by 138 kV and 69 kV transmission lines, and addresses reliability issues for AEP, Oncor and other TSPs.

Additionally, the Far West Texas Project would also allow flexibility for future 345 and 138 kV lines, future autotransformers, and additional connections between TSPs as needs dictate. It is the best overall solution to create a resilient transmission system in Far West Texas, an area that is expected to have substantial future load growth and generation penetration.

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RE: Far West Texas project

On June 13, 2017 the Electric Reliability Council of Texas (ERCOT) Board of Directors recommended the following Tier 1 transmission project as needed to support the reliability of the ERCOT Regional transmission system:

Far West Texas project:

- Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers
- Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV Switch Station. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV Switch Station to create the new Odessa EHV – Riverton 345 kV line
- Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers
- Construct a new approximately 68-mile 345 kV line from Solstice Switch Station to Bakersfield Station on double-circuit structures with one circuit in place

Additional details on this project are included in the Attachment A to this letter.

This project was supported throughout the ERCOT planning process, which included participation of all market segments through the ERCOT RPG. ERCOT's recommendation to the Board was reviewed by the ERCOT Regional Planning Group and the ERCOT Technical Advisory Committee (TAC). ERCOT staff looks forward to the successful completion of the work and is ready to assist you with any planning and operations related activities.

Should you have any questions please contact me at any time.

Sincerely,

D. W. Rickerson
Vice President, Grid Planning and Operations
Electric Reliability Council of Texas

cc:
Shawnee Claiborn-Pinto, PUCT
Bill Magness, ERCOT
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ERCOT Independent Review of the AEPSC and Oncor Far West Texas Project

Version 1.0

Document Revisions

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1. Executive Summary

Over the past several years the load on the Wink – Culberson – Yucca Drive 138 kV transmission loop ("Culberson loop") and the load in the Barilla Junction area have experienced high load growth. Oncor has projected annual load growth rates as high as 11% over the next five years on the Culberson loop. Additionally, both areas, located in Far West Texas, have had an increase in requests for generator interconnections. Over 1,600 MW of solar resources are expected to come online in Pecos and Southwest Upton Counties between 2016 and 2020.

On April 20, 2016, Oncor and AEPSC submitted the Far West Texas Project (FWTP) to the Regional Planning Group (RPG) to address the transmission needs both in the Culberson loop area and the Barilla Junction area. The proposed project was estimated to cost $423 million and classified as a Tier 1 project. The proposed in-service date range for the FWTP was 2021-2022.

Based on the FWTP proposal, ERCOT completed this independent review to determine the system needs and address those needs in a cost-effective manner while providing the flexibility to meet potential load and generating capacity growth in this region. ERCOT also performed sensitivity studies in compliance with the ERCOT Planning Guide.

Based on the forecasted loads and scenarios analyzed, ERCOT determined that there is a reliability need to improve the transmission system in Far West Texas. After consideration of the project alternatives, ERCOT concluded that the upgrades identified in Option 2 meet the reliability criteria in the most cost effective manner and have multiple expansion paths to accommodate future load growth in the area of study. Option 2 is estimated to cost $336 million and is described as follows:

- Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers
- Construct a new, approximately 85-mile, 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station, Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV Switch Station. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV Switch Station to create the new Odessa EHV – Riverton 345 kV Line
- Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformers
- Construct a new, approximately 68-mile, 345 kV line from Solstice Switch Station to Bakersfield Station on double-circuit structures with one circuit in place

Although this option is not the exact configuration included in the FWTP proposal, it is a subset of that configuration with two autotransformer additions. ERCOT has determined that the alternative transmission expansion option, Option 2, will provide the most cost-effective configuration to meet the load forecast developed from contractual agreements. It will also allow a number of different possible expansion options that could augment the Far West Texas transmission grid load serving capability beyond the forecasts developed exclusively from committed load additions.

2. Introduction

Over the past several years the Far West Texas Weather Zone has experienced high load growth. Between 2010 and 2016 the average annual growth rate was roughly 8%. This strong growth rate was primarily driven by increases in oil and natural gas related demand. The most recent ERCOT 90th percentile summer non-coincident peak load forecast projects an average annual Far West Weather Zone growth rate of about 2.4% between 2016 and 2020.

Figure 2.1 shows historic and projected summer non-coincident peak load levels for the Far West Weather Zone.

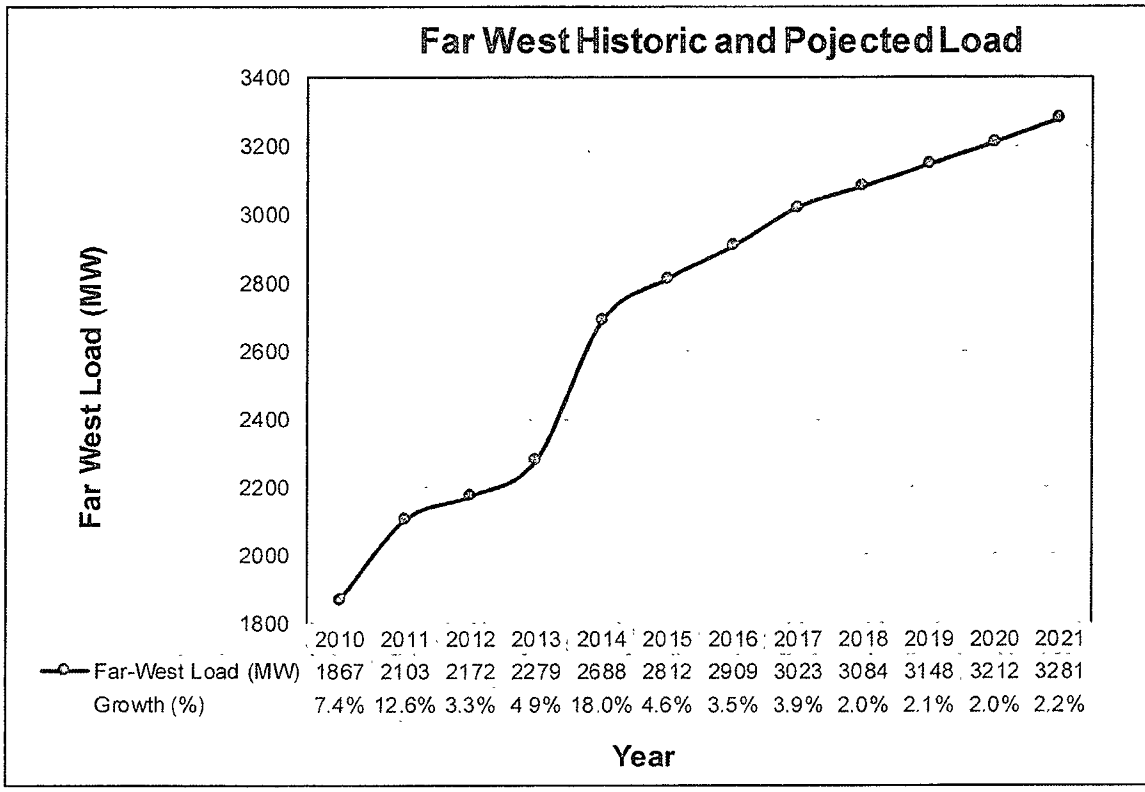

Figure 2.1: Far West Weather Zone historic peak load and ERCOT 90th percentile summer non-coincident peak load forecast

The Transmission Service Providers (TSPs) in the area including Oncor, TNMP and AEPSC have also identified high load growth rates concentrated in the Delaware Basin area. Oncor has projected annual load growth rates ranging as high as 11% over the next five years within a portion of the Far West Weather Zone, including Culberson, Reeves, Loving, Ward and Winkler Counties, based on committed customer load requests

The area southwest of Odessa, served by the 69 kV and 138 kV lines between Permian Basin, Barilla Junction, Fort Stockton Plant, and Rio Pecos stations ("Barilla Junction area") has seen increased load growth along with solar generation development. AEPSC has projected that the Barilla Junction area load will grow to over 500 MW by 2021 with over 160 MW being served by the Yucca Drive – Barilla Junction 138 kV line alone. There are over 1,600 MW of solar resources that meet the conditions of Planning Guide Section 6.9 for inclusion in the base cases and that are expected to come online in Pecos and Southwest Upton Counties between 2016 and 2020. These generators are listed in Table 2.1

Table 2.1 Solar Generation coming online in Pecos and Upton between 2016 and 2020

INR	Project Name	Fuel	Projected COD	Total Capacity	County
12INR0059b	Barilla Solar 1B	Solar	7/1/2016	7	Pecos
16INR0048	RE Rose Rock Solar	Solar	10/31/2016	160	Pecos
16INR0073	East Pecos Solar	Solar	12/1/2016	120	Pecos
16INR0065	Castle Gap Solar	Solar	1/11/2017	117	Upton
15INR0070_1	West Texas Solar	Solar	2/1/2017	110	Pecos
15INR0045	Riggins Solar	Solar	2/16/2017	150	Pecos
15INR0070_1b	Pearl Solar	Solar	4/28/2017	50	Pecos
16INR0065b	SP-TX-12-Phase B	Solar	8/15/2017	120	Upton
16INR0065a	Castle Gap Solar 2	Solar	9/6/2017	63	Upton
17INR0020a	RE Maplewood 2a Solar	Solar	10/1/2018	100	Pecos
16INR0114	Upton Solar	Solar	12/1/2018	102	Upton
15INR0059	Pecos Solar I	Solar	1/1/2019	108	Pecos
17INR0020b	RE Maplewood 2b Solar	Solar	5/16/2019	200	Pecos
17INR0020c	RE Maplewood 2c Solar	Solar	1/1/2020	100	Pecos
17INR0020d	RE Maplewood 2d Solar	Solar	7/15/2020	100	Pecos

On April 20, 2016, Oncor and AEPSC submitted the Far West Texas Project (FWTP) to the Regional Planning Group (RPG) to address the transmission needs both in the Barilla Junction area and the Wink – Culberson – Yucca Drive 138 kV transmission loop ("Culberson loop"). This project was estimated to cost $423 million and was classified as a Tier 1 project. Figure 2.2 shows the proposed FWTP. The major components of this project proposal were:

- A new 101-mile Odessa EHV – Riverton 345 kV line on a double circuit structure with a single circuit installed
- Expansion of the Riverton Switch Station to install a 3-breaker 345 kV ring-bus arrangement with one 600 MVA, 345/138 kV autotransformer
- Expansion of the Solstice Switch Station to install a 3-breaker 345 kV ring-bus arrangement with one 675 MVA, 345/138 kV autotransformer
- A new 66-mile Riverton – Solstice 345 kV line on a double circuit structure with a single circuit installed
- A new 345 kV Lynx Switch Station with a 5-breaker 345 kV ring-bus arrangement and one 675 MVA, 345/138 kV autotransformer
- A new 59-mile Solstice – Lynx 345 kV Line on a double circuit structure with a single circuit installed
- A new 9-mile Lynx – Bakersfield 345 kV Line on a double circuit structure with a single circuit installed

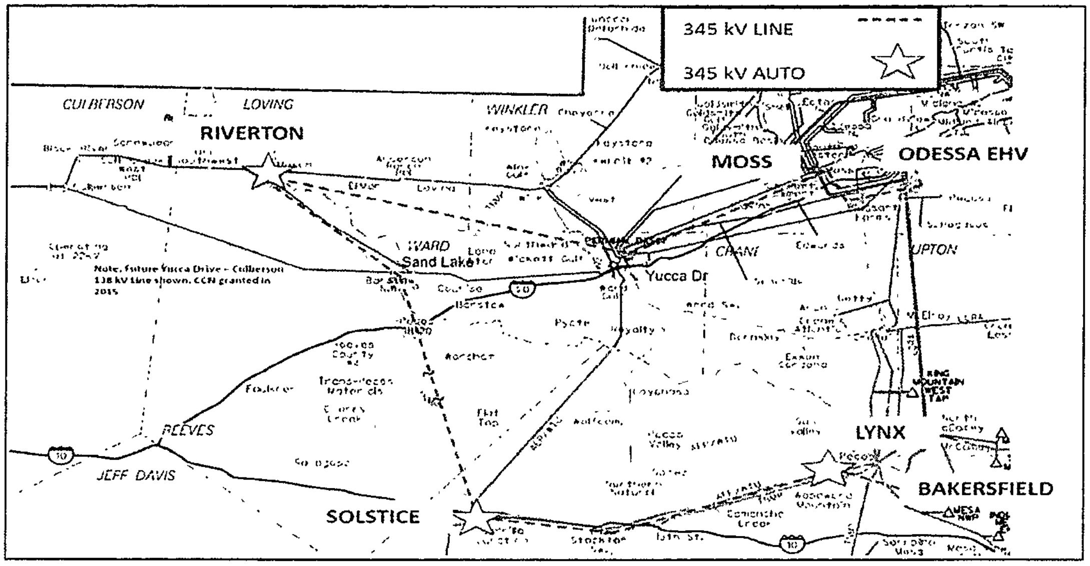

Figure 2.2: Proposed Far West Texas Project

Based on the FWTP proposal, ERCOT completed this independent review to determine the system needs in the Barilla Junction and Culberson loop areas and address those needs in a cost-effective manner while providing the flexibility to meet potential load and generating capacity growth in this region.

3. Study Assumption and Methodology

ERCOT performed studies under various system conditions to evaluate the system need and identify a cost-effective solution to meet those needs in the area. The assumptions and criteria used for this review are described in this section.

3.1. Study Assumption

The primary focus of this review are the Barilla Junction Area and Wink – Culberson – Yucca Drive loop transmission system.

Figure 3.1 shows the system map of the study area The Barilla Junction and Culberson loop areas are highlighted in rectangles.

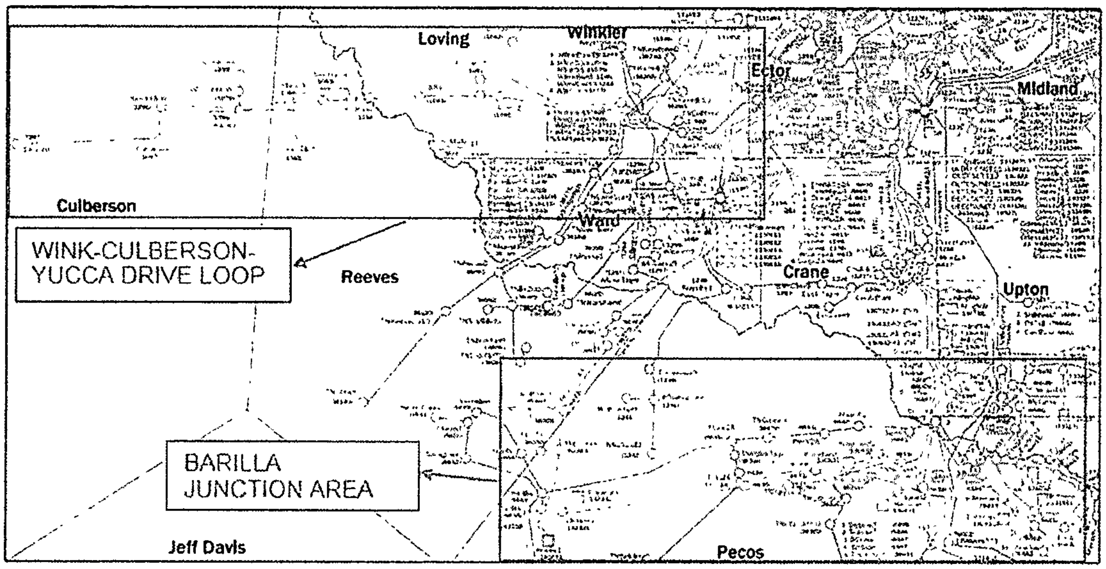

Figure 3.1: Transmission System Map of Study Area

3.1.1. Reliability Cases

The following starting cases were used in the study:

- The 2021 West/Far West (WFW) summer peak case from the 2016 RTP (based on the 2015 Steady State Working Group (SSWG) cases)
- The 2022 Dynamic Working Group summer peak flat start case

3.1.2. Transmission Topology

The starting case was modified based on input from AEPSC and Oncor to include topological changes, switched shunt additions and load additions in the study area. AEPSC provided system changes to the 138 kV line from Pig Creek to Yucca Drive via Gas Pad Tap. This section was upgraded to 966 MVA. The changes also included a switched shunt device at Hackberry Draw Tap 138 kV substation.

Oncor also provided topological updates to the Wink – Culberson – Yucca Drive loop. The changes included the new Riverton and Mentone substations, and a new Riverton-Mentone-Sand Lake 138 kV line along with other new buses and branches to accommodate new load additions in the Culberson loop. The changes also included a switched shunt added to the Whiting Oil 138 kV bus.

3.1.3. Study Case Loads and Potential Loads

The TSPs also provided data which increased the load in the Barilla Junction and Culberson loop areas. The original Oncor and AEPSC RPG submittal data included about 425 MW of load in the Culberson loop area and 511 MW in the Barilla Junction area by year 2021. These projections were later modified by Oncor to include additional confirmed load contracts for the Culberson loop during the ERCOT independent review. AEPSC also provided updated load information for the Barilla Junction area and some of the loads originally designated as conforming were modified to be non-conforming. After all the changes were incorporated the "Study Case" for 2021 had a total projected load of 533 MW along the Culberson loop and 511 MW of total load in the Barilla Junction area. Both AEPSC and Oncor met with ERCOT and shared information on the signed customer agreements and confirmed these proposed load additions.

Sensitivity cases were also created to reflect higher load projections from Oncor and AEPSC. These cases contained additional customer load requests that did not yet have firm commitment at the time of this independent review. To reflect this "Potential" load growth, the load was increased by 277 MW in the Culberson loop and 57 MW in the Barilla Junction area above the Study Case load. The total load in the Potential Load Case was approximately 810 MW and 568 MW in the Culberson loop and Barilla Junction area, respectively, for the Potential Load sensitivity.

3.1.4. Generation

Planned generators in the Far West and West Weather Zones that met Planning Guide Section 6.9 conditions for inclusion in the base cases (according to the 2016 October Generation Interconnection Status report), which were not included in the RTP cases, were added. The added generators are listed in Table 3.1.

Key assumptions applied in this study include the following:

- Wind generation in West and Far West weather zones were set to have a maximum dispatch capability of 2.6% of their rated capacity. This assumption was in accordance with the 2016 Regional Transmission Plan Study Scope and Process document[1].
- Solar generation was set at 70% of their rated capacity in accordance with the 2016 Regional Transmission Plan Study Scope and Process document.

Table 3.1 Added Generators That Met Planning Guide Section 6.9 Conditions (2016 October GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
16INR0023	BNB Lamesa Solar (Phase I)	102	Solar	Dawson	Far West
16INR0065a	Castle Gap Solar 2	63	Solar	Upton	Far West
17INR0020a	RE Maplewood 2a Solar	100	Solar	Pecos	Far West
17INR0020b	RE Maplewood 2b Solar	200	Solar	Pecos	Far West
17INR0020c	RE Maplewood 2c Solar	100	Solar	Pecos	Far West
17INR0020d	RE Maplewood 2d Solar	100	Solar	Pecos	Far West
15INR0061	Solaire Holman 1	50	Solar	Brewster	Far West

3.1.5. No Solar Scenarios

The Far West and West Weather Zones have a significant amount of solar generation, and the maximum output of solar generation modeled in the Study Case and the Potential Load Case was

[1] http://www.ercot.com/content/wcm/key_documents_lists/77730/2016_RTP_Scope_Process_v1.3_clean.pdf

1,340 MW based on limiting the dispatch to about 70% of maximum capacity (maximum capacity was about 1,912 MW). To study system conditions when solar generation is not available, a 9:00 pm summer peak load condition case was created for both the Study Cases and Potential Load Cases. To create this "No Solar" peak condition, the load in the Far West Weather Zone was reduced by 6% based on a review of the historic Far West Weather Zone summer peak conditions from 2014-2016 at the time of peak and at 9:00 pm when the sun has set and solar generation output is expected to be near zero. Therefore, the load was scaled down in the Far West Weather Zone to reflect expected demand conditions at 9:00 pm for the "No Solar" scenarios.

3.1.6. Capital Cost Estimates

Capital costs estimates for transmission facilities were provided by Oncor, AEPSC and LCRA TSC. These cost were provided for individual transmission facilities and ERCOT used those values to calculate total project costs for various project options.

3.2. Criteria for Violations

All the violations identified in this report used the criteria described in this section.

All 100 kV and above busses, transmission lines, and transformers in the study region were monitored (excluding generator step-up transformers).

- Thermal violation
  - Use Rate A for Normal Conditions
  - Use Rate B for Emergency Conditions
- Voltage violation criteria
  - 0.95 < V pu < 1.05 Normal
  - 0.90 < V pu < 1.05 Emergency
  - Post Contingency voltage deviations
    - > 8% on non-radial load buses
- Voltage Stability Analysis
  - PV calculations for load transfer (Culberson loop)

3.3. Study Tools

ERCOT utilized the following software tools for the independent review of the Far West Texas Project:

- PSS/e version 33 was used to perform the dynamic stability analysis and to incorporate the TSP changes (idevs) in the initial steady-state case
- PowerWorld Simulator version 19 for SCOPF and steady state contingency analysis
- VSAT version 15 was used for voltage stability analysis
- UPLAN

4. Project Need

The need for a transmission improvement project was evaluated for the Study Case with both the base case and "No Solar" scenarios. The steady state analysis results showed transmission line overloading in the Barilla Junction area and voltage instability (unsolved contingencies) in the Culberson loop area under N–1 contingency analysis. The results of the steady state violations are summarized in Tables 4.1 – 4.4.

Table 4.1 2021 Thermal Overloading in the Study Region under N-1 Conditions

Element	Length (miles)	Study Case	No Solar Case
16th Street TNP to Woodward2 138 kV ckt 1	31.8	101%	115%
Rio Pecos to Woodward2 138 kV ckt 1	1.9	No Violation	106%
Rio Pecos to Woodward1 Tap 138 kV ckt 1	2.2	No Violation	106%
Tombstone to Woodward1 Tap 138 kV ckt 1	15 7	No Violation	106%

Table 4.2 2021 Unsolvable contingencies

#	Contingency (Category)	Study Case	No Solar Case
1	CEII	Unsolved	Unsolved

Table 4.3 2021 Voltage Violations in the Study Region under N-1 Conditions

Bus	Nominal Voltage (KV)	Study Case	No Solar Case
Salt Creek South Poi	138	0.873	0.893
Black River	138	0.878	0.896
Mentone SW	138	0.880	0.897
Mentcryo	138	0.885	0.898
Coalsndr	138	0 880	0.898
Sandlake	138	0.881	0.898
Sand Bend Poi	138	0 877	0.898
Culberson2	138	0.880	0.898
Orla Plant	138	0.865	0.899
Culberson	138	0.881	0.899
Culberson Wind Farm	138	0.881	0.899
Elmar	138	0.890	No Violation
Kunitz	138	0.883	No Violation
Mason (Oncor)	138	0.885	No Violation
Orla Southwest Poi	138	0.869	No Violation
Riverton	138	0.878	No Violation
Salt Creek West Poi	138	0.880	No Violation
Screwbean Tap	138	0.881	No Violation

Table 4.4 2021 Voltage Deviations in the Study Region under N-1 Conditions

Bus	Nominal Voltage (KV)	Study Case	No Solar Case
Kunitz	138	< 8%	9.2%
Mason (Oncor)	138	< 8%	8.7%
Orla Southwest Poi	138	< 8%	9.0%
Pig Creek Tap	138	< 8%	8.6%
Riverton	138	< 8%	8.8%
Salt Creek West Poi	138	< 8%	9.1 %
Screwbean Tap	138	< 8%	9.1%
Wolfbone Tap TNP	138	< 8%	10.0%
Woodward 1 Tap	138	< 8%	8.5%
Woodward 1	138	< 8%	8.5%

The unsolvable contingency identified in Table 4.2 and voltage violations listed in Table 4 4 indicated a local voltage stability challenge in the Culberson loop area. The detailed steady state results for the Study Case with and without solar can be found in the Appendix

Figure 4.1 shows the thermal violations seen in the Study case.

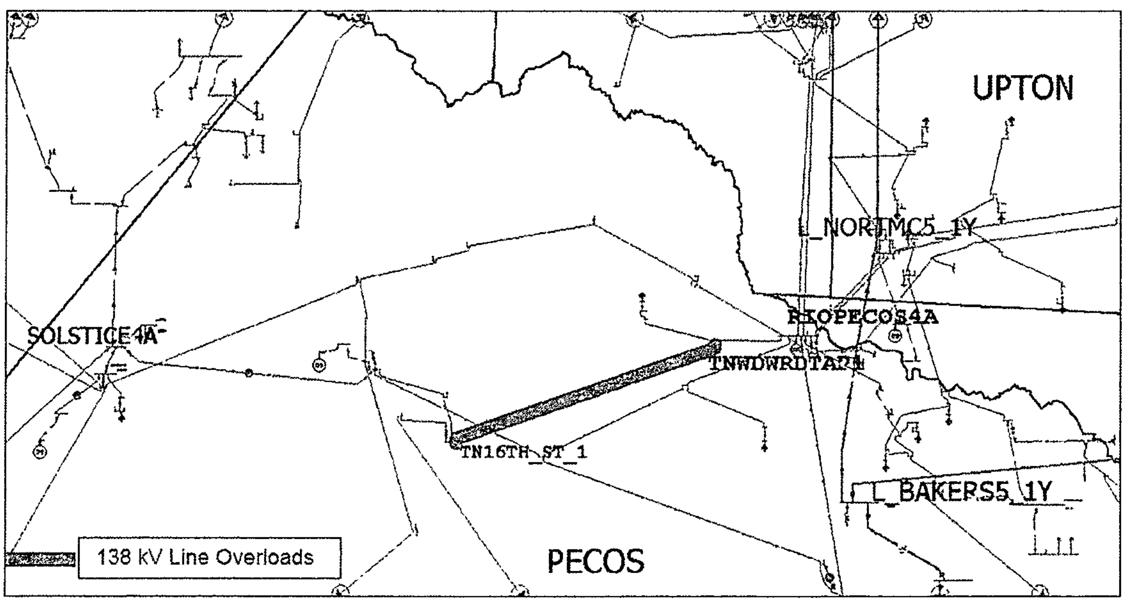

Figure 4.1: Study Case Thermal Violations in Study area

Figure 4.2 shows the voltage violations seen in the Study case.

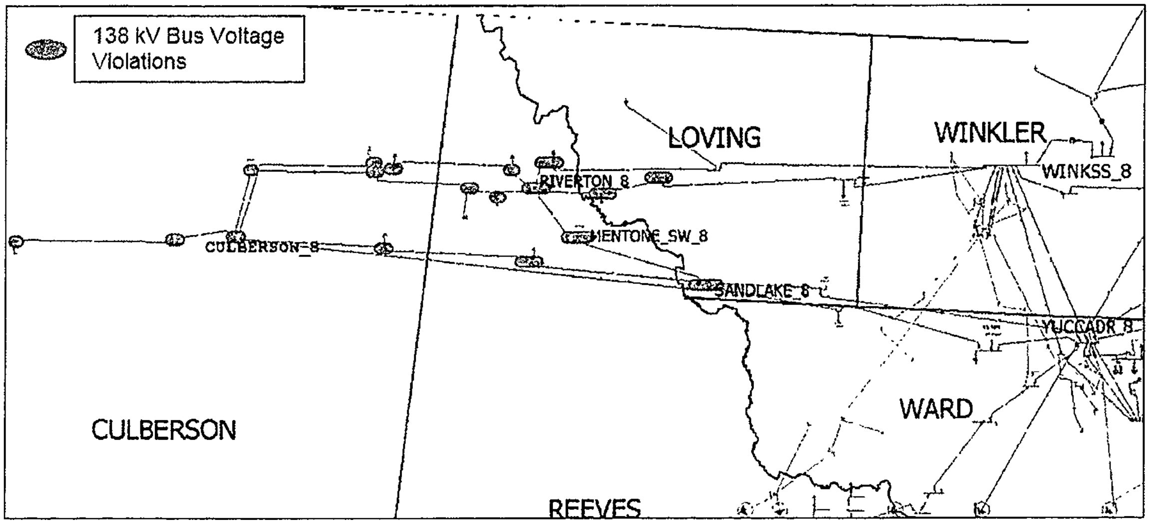

Figure 4.2: Study Case Voltage Violations in Study area

Figure 4.3 shows the thermal violations seen in the No Solar case.

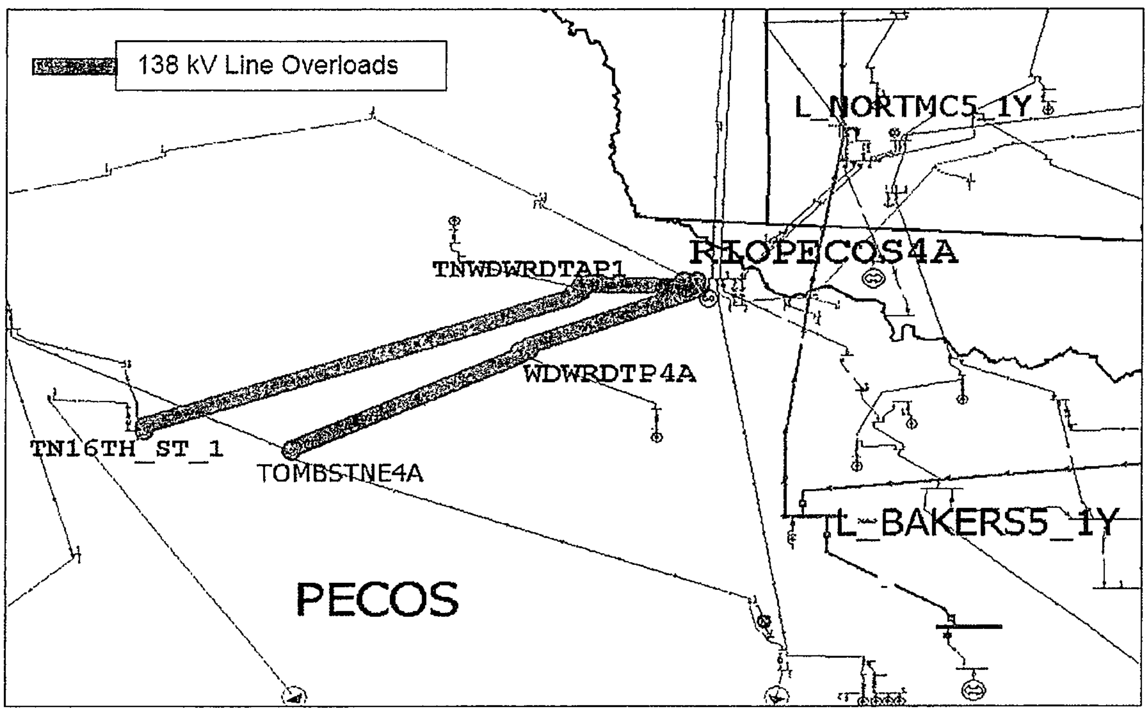

Figure 4.3: No Solar Case Thermal Violations in Study area

Figure 4.4 shows the voltage violations seen in the No Solar case.

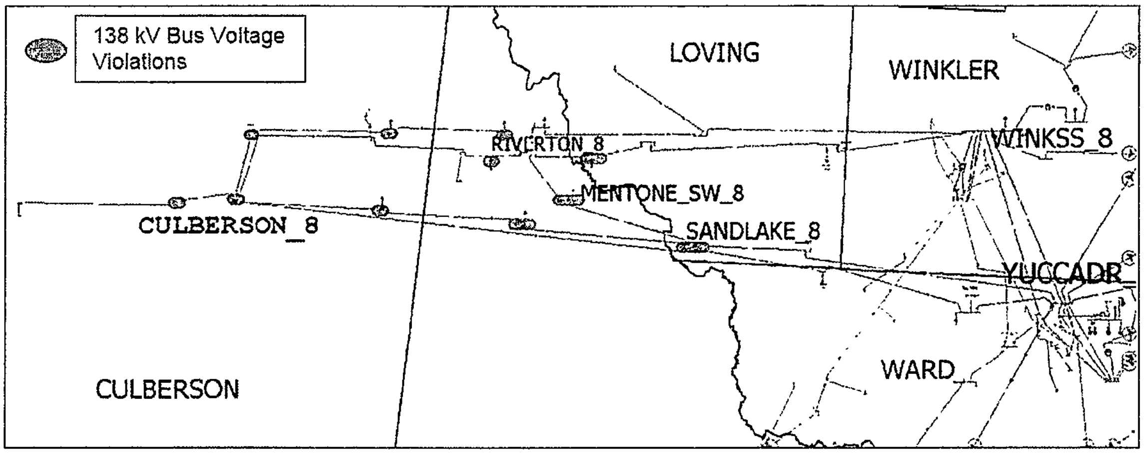

Figure 4.4: No Solar Case Voltage Violations in Study area

Both steady state and dynamic stability analyses identified reliability issues under the NERC and ERCOT reliability criteria.

5. Project Options

To address the reliability needs in the study area, ERCOT initially examined the FWTP proposal submitted by the TSPs in combination with nearly 40 alternatives.

5.1. Initial Options

An initial set of options (alternatives) was developed to address the identified reliability criteria violations for the Study Case while also considering an upgrade path to address potential needs in the future. This was accomplished by beginning with the simplest 138 kV expansion alternatives and then expanded to address performance violations. ERCOT also attempted to minimize the project cost. The ERCOT 2016 Long-Term System Assessment[2], which identified a long-term need for a project in the area, was also considered when developing the initial set of options.

The 40 alternatives could be described as variations of about 9 different transmission solutions, the variations created by using different 138 kV and 345 kV voltage class facilities; various termination points for new transmission lines; and various reactive compensation. Accordingly, diagrams of project options with cost estimates and a summary of reliability performance findings are provided in the Appendix for the 9 major transmission solutions.

Cost and reliability performance comparisons were used to narrow the 9 major solution options to the short-listed options discussed next. Generally, the short-listed options are also variations of the FWTP originally proposed by the TSPs.

5.2. Short-Listed Options

Among all the initial options, a final number of four options were studied further. The detailed description of the four short-list options are provided below and diagrams for these are included in the Appendix.

- **Option 1**
    - Install a new 200 MVAR Dynamic Synchronous Condenser at Mentone 138 kV substation
    - Install a new 200 MVAR Dynamic Synchronous Condenser at Culberson 138 kV substation
    - Construct a new approximately 85-mile 345 kV line operating at 138 kV on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV to create the new Odessa EHV - Riverton 345 kV line operating at 138 kV.
    - Build a new McCamey – Fort Stockton 345 kV double circuit line operating at 138 kV (requiring approximately 47-miles of new Right of Way)
    - Build a new Pig Creek – Fort Stockton 345 kV single circuit line operating at 138 kV (requiring approximately 39-miles of new Right of Way)
    - Install a new 50 MVAR capacitor bank each at Mentone and Salt Creek 138 kV substations

[2] http://www.ercot.com/content/wcm/lists/89476/2016_Long_Term_System_Assessment_for_the_ERCOT_Region.pdf

- Install a new 18 MVAR capacitor bank each at Orla, Elmar, Loving and Alamito Creek 138 kV substation
- Install a new 3.6 MVAR capacitor bank Espy Wells 69 kV substation
- Install a new 10.8 MVAR capacitor bank at Shafter Goldmine 69 kV substation
- Install a new 7.2 MVAR capacitor bank at Sanderson TNP 69 kV substation

The total cost estimate for Option 1 is approximately $464 Million.

- **Option 2**
  - Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV to create the new Odessa EHV – Riverton 345 kV Line
  - Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 68-mile 345 kV line from Solstice Switch Station to Bakersfield station on double-circuit structures with one circuit in place

The total cost estimate for Option 2 is approximately $336 Million.

- **Option 3**
  - Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV to create the new Odessa EHV – Riverton 345 kV Line
  - Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Expand the Sand Lake Switch Station to install a 345 kV ring-bus arrangement with one 600 MVA, 345/138 kV autotransformer
  - Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer
  - Construct a new approximately 41-mile 345 kV line on double-circuit structures with one circuit in place, Sandlake – Solstice 345 kV single circuit line (requiring approximately 41 miles of new Right of Way).
  - Add a second circuit to the Riverton – Mentone – Sand Lake 345 kV to create a Riverton – Sand Lake 345 kV line on the existing Riverton – Mentone – Sandlake 345 kV line operating at 138 kV.

  - Construct a new approximately 68-mile 345 kV line from Solstice Switch Station to Bakersfield station on double-circuit structures with one circuit in place

The total cost estimate for Option 3 is approximately $446 Million.

- **Option 4**
  - Option 4 is same as Option 3 with an additional new 200 MVAR Synchronous Condenser at Culberson 138 kV substation.

The total cost estimate for Option 4 is approximately $501 Million.

6. Steady-State Performance of Short-listed Options

To compare and contrast each of the options several analyses were performed. This Section discusses the performance of the four short-listed options under N-1 (NERC P1, P2-1 and P7) steady state contingency conditions for the studied scenarios.

Table 6.1 Steady State Reliability Assessment of All Final Options under N-1 (NERC P1, P2-1 and P7)

Load Level	Violation Type	Case	Option 1	Option 2	Option 3	Option 4
Study Case (533 MW in Culberson loop; 511 MW in Barilla Junction area)	Thermal	With Solar	No Violations	No Violations	No Violations	No Violations
		No Solar	No Violations	No Violations	No Violations	No Violations
	Voltage	With Solar	No Violations	No Violations	No Violations	No Violations
		No Solar	No Violations	No Violations	No Violations	No Violations
Potential Load Case (810 MW in Culberson loop; 568 MW in Barilla Junction area)	Thermal	With Solar	*Violations*	*Violations*	No Violations	No Violations
		No Solar	*Violations*	*Violations*	No Violations	No Violations
	Voltage	With Solar	No Violations	*Violations*	No Violations	No Violations
		No Solar	No Violations	*Violations*	No Violations	No Violations

The steady state results showed that all of the four options addressed the reliability needs in the Culberson loop and Barilla Junction area with Study Case load conditions. In the Potential Load scenario there were violations for Options 1 and 2. Option 3 and 4 showed no violations even under the Potential Load scenario. Option 3 had a voltage deviation of over 8% at Orla 138 kV substation in the Potential Loads case. It should be noted that there were some violations that were more severe in the cases that had solar generation than in the No Solar scenarios as these cases all reflected summer peak loading conditions while the No Solar cases had a slightly lower load level. A complete list of branch and voltage violations and the corresponding contingencies are provided in the Appendix.

7. Voltage Stability Analysis

A voltage stability analysis was conducted for the Culberson loop area for all short-listed options. The No Solar scenario represents the most stressed system condition from a voltage stability perspective and was therefore tested for all of the short-listed options. A Power-Voltage (PV) stability assessment was used to proportionally increase the load in the Culberson loop until a voltage collapse identified the maximum load serving capability for these options. The PV analysis included NERC P1, selected P6, and P7 contingency events. Table 7.1 shows the maximum load in the Culberson loop area to be reliably served as identified in the voltage stability analysis. All of the short-listed options provide more than a 10% voltage stability load margin when compared to the Study Case load level.

Table 7.1 Voltage Stability Assessment of All Final Options

Description	Option 1	Option 2	Option 3	Option 4
PV Results Culberson loop Load Served (MW)	917	717	917	1037

8. Economic Analysis

Although this RPG project is driven by reliability needs, ERCOT also conducted an economic analysis to compare the relative performance of each of the final options in terms of production cost savings.

The base case for this economic analysis used the 2022 economic case built for the 2016 RTP as the starting case. The topology changes and generation additions were similar to the steady state base case built. The load was modified to reflect the demand in the RPG proposal, but a 50/50 load scenario was used in ERCOT economic analysis, whereas the steady state analysis used a 90/10 load scenario. ERCOT modeled each of the four final options and performed production cost simulations for the year 2022. The annual production cost under each select option was compared to the option yielding the highest annual production cost in order to obtain a relative annual production cost saving for each option.

As shown in Table 8.1, the results indicates that Options 2 to 4 have over $6 million annual production cost savings compared to Option 1. This relative improvement in savings is due to the loss savings achieved by operating the new transmission lines at 345 kV. This apart, Options 2 to 4 showed no significant difference in congestion.

Table 8.1 Relative annual production cost savings (referenced to Option 1), in $ Million

Option	Option 1	Option 2	Option 3	Option 4
Relative Annual Production Cost Savings (referenced to Option 1)	-	6.2	6.6	6 6

9. Final Options Comparison

As shown in Table 9.1, a comparison of study results for the short-listed options shows that Option 2 met the system reliability criteria under the Study Case load conditions while deferring more than $100 million in capital expenditures when compared to the other options. Option 2 also resulted in lower system production costs when compared to Option 1 and was expected to provide an adequate voltage stability margin.

Although Option 2 did not meet the system reliability criteria for the Potential Load scenario, there are a number of different expansion options that can augment the load serving capability of Option 2 as the outlook for greater load and generation resources in this region becomes more certain. More specifically, as indicated by these studies, Option 3 or 4 are two possible options that could be constructed from Option 2 to meet applicable transmission planning criteria while serving significantly higher loads in this region. Option 2 also aligns with the long-term needs identified for the area in the 2016 Long-Term System Assessment.

Table 9.1 Options Comparison

Description	Option 1	Option 2	Option 3	Option 4
System Performance – Study Case	Met criteria	Met criteria	Met criteria	Met criteria
System Performance – Potential Load Case	Criteria not Met	Criteria not	Met criteria	Met criteria
Capital cost ($ Million)	464	336	446	501
PV Results Culberson Load Served (MW)	917	717	917	1037
Relative Production Cost Savings ($ Million)	-	6 2	6.6	6.6
Total System Loss Reduction (MW)	10.4	31.2	34 4	34.4
New Right of Way Required (Miles)	187	169	235	235

Additional studies were performed to verify that Option 2 will provide the most cost-effective configuration to meet the Study Case load conditions consistent with ERCOT Protocol and Planning Guide requirements.

9.1. Final Steady-State Performance Test

NERC P3, P6-1, P6-2 and P6-3 contingency analyses were performed under the Study Case load conditions with Option 2. This Option had no voltage collapse for these contingencies at the Study Case load level with both base case generation and with No Solar conditions applied.

Additionally, P2.2-2.3 (EHV), P4.1-P4.5 (EHV) and P5 (EHV) contingencies for the West and Far West Weather Zones were applied to Option 2 using the Study Case load levels with the base case generation and with No Solar conditions applied. There were no criteria violations found for Option 2 based on the conditions studied.

Figure 9.1 shows Option 2 applied to the study area.

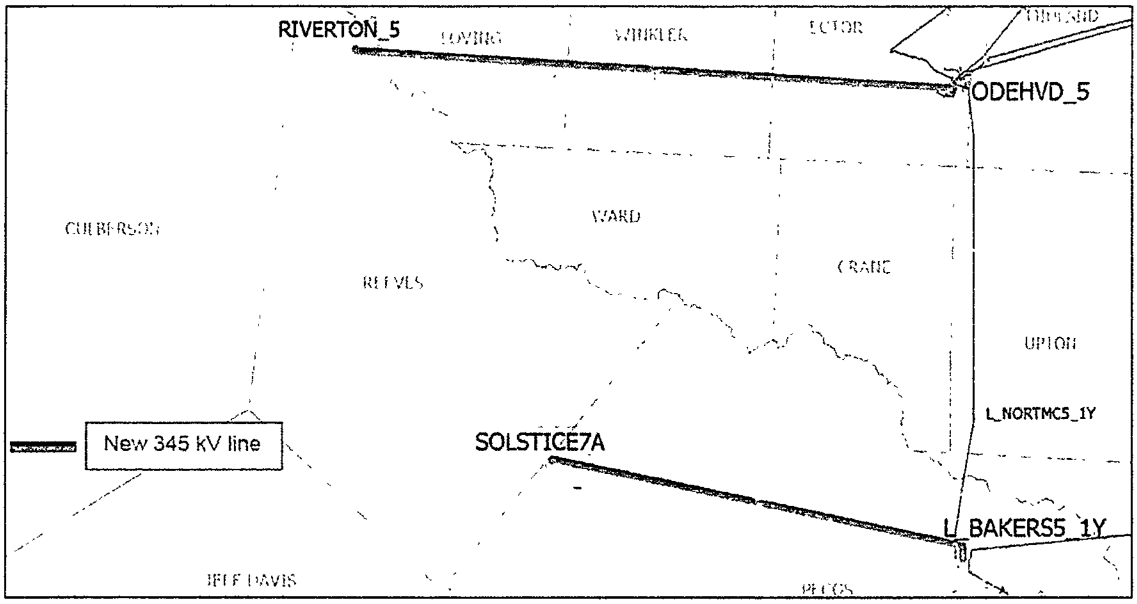

Figure 9.1: Option 2 applied to the Study area

9.2. Dynamic Performance

The majority of the loads in the study area were assumed to be oil and gas customers who employ voltage sensitive electric equipment in their operations. As indicated by the TSPs, heavy motor load was assumed to represent the load characteristic in the study area. The preferred Option 2 was tested using time domain dynamic stability simulations including a dynamic load model to quantify system stability.

It was assumed that if simulations indicated an acceptable (stable) system response following severe events and/or three-phase faults, the stability response would also be acceptable for the same events with single-line-to-ground (SLG) fault. If a potential stability issue was observed, the simulation was rerun with SLG faults to ensure a stable system response following a NERC planning events when applicable, thereby demonstrating compliance with NERC planning standards and ERCOT reliability criteria. Selected ERCOT transmission buses were monitored for frequency and voltage deviations. Nearby synchronous generating units were monitored for angular separation.

The limiting events identified in the PV analysis were studied in the dynamic simulation.

The dynamic event definitions included the removal of all elements that the protection system and other automatic controls are expected to disconnect for each event.

The dynamic simulation results showed that with Option 2 upgrades implemented the area of concern met the NERC and ERCOT reliability criteria. Detailed dynamic simulation results are presented in the Appendix.

10. Sensitivity Studies

Sensitivity studies were performed to ensure compliance with Planning Guide requirements.

10.1. Generation Sensitivity Analysis

ERCOT performed a generation sensitivity analysis based on Planning Guide Section 3.1.3(4) (a). Generator additions with signed Interconnection Agreements but that did not meet Planning Guide Section 6.9 conditions for inclusion in the base cases at the beginning of the study in the study region were added to the Study Case (based on the 2017 March Generator Interconnection Status report). In between the October 2016 Generator Interconnection Status and March 2017 Generator Interconnection Status reports there were another five units that met Planning Guide Section 6.9 conditions. These units were also added in this sensitivity study. Table 10.1.1 and 10.1.2 show all the generators that were added to the Study Case for this analysis.

Table 10.1.1 Generators Met Planning Guide Section 6.9 Conditions (2017 March GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
14INR0044	West of Pecos Solar	100	Solar	Reeves	Far West
15INR0064	BearKat Wind A	197	Wind	Glasscock	Far West
17INR0027	Dermott Wind 1	250	Wind	Scurry	West
15INR0064b	BearKat Wind B	163	Wind	Glasscock	Far West
17INR0027b	Coyote Wind	250	Wind	Scurry	West

Table 10.1.2 Generators with SGIA That Did Not Meet Planning Guide Section 6.9 Conditions (2017 March GIS report)

GINR Number	Project Name	MW	Fuel	County	Weather Zone
13INR0023	Texas Clean C	240	Coal	Ector	Far West
16INR0010	FGE Texas 1	745	Gas	Mitchell	West
17INR0010	FGE Texas II	799	Gas	Mitchell	West
12INR0059c	Barilla Solar 2	21	Solar	Pecos	Far West
16INR0019	Capricorn Ridge Solar	100	Solar	Coke	West
16INR0023b	Lamesa Solar B (Phase II)	98	Solar	Dawson	Far West
12INR0060	Infinity Live Oak Wind	201	Wind	Schleicher	West
16INR0086	Cactus Flats Wind	150	Wind	Concho	West
13INR0020b	Rattlesnake W2	158	Wind	Glasscock	Far West

The purpose of this generation sensitivity analysis was to evaluate the effect of the above mentioned generation units on the recommended transmission project. It was found that the Study Case violations did not entirely disappear with these additional generations. The violations seen for the Study Case with the generation units meeting Planning Guide Section 3.1.3(4) (a) criteria are summarized in Tables 10.2.1 – 10.2.4.

Table 10.2.1 Thermal Overloading in the Study Region under N-1 Conditions, With Generation meeting Planning Guide Section 3.1.3(4) (a)

Element	Length (miles)	Study Case	No Solar
16th Street TNP to Woodward2 138 kV ckt 1	31.8	No Violation	110%
Rio Pecos to Woodward2 138 kV ckt 1	1.9	No Violation	101%
Tombstone to Woodward1 Tap 138 kV ckt 1	15.7	No Violation	101%

Table 10.2.2 Unsolvable contingencies, With Generation meeting Planning Guide Section 3.1.3(4) (a)

#	Contingency (Category)	Study Case	No Solar
1	CEII	Unsolvable	Unsolvable

Table 10.2.3 Voltage Deviations in the Study Region under N-1 Conditions, With Generation meeting Planning Guide Section 3.1.3(4) (a)

Bus	Nominal Voltage (KV)	Study Case	No Solar
Wolfbone Tap TNP	138	< 8%	8.8%
Woodward 1 Tap	138	< 8%	8.7%
Woodward 1	138	< 8%	8.7%

Table 10.2.4 Voltage Violations in the Study Region under N-1 Conditions, With Generation meeting Planning Guide Section 3.1.3(4) (a)

Bus	Nominal Voltage (KV)	Study Case	No Solar
Sandlake	138	0.898	No Violation
Coalsndr	138	0.888	No Violation
Mentone SW	138	0.882	No Violation
Culberson2	138	0.881	No Violation
Screw bean Tap	138	0.878	No Violation
Kunitz	138	0.877	No Violation
Salt Creek West Poi	138	0 877	No Violation
Culberson Wind Farm	138	0.876	No Violation
Culberson	138	0.876	No Violation
Black River	138	0.871	0.899
Orla Southwest Poi	138	0.869	0.892
Riverton	138	0 869	0 896
Sand Bend Poi	138	0.867	0.895
Orla Plant	138	0 867	0.889
Salt Creek South Poi	138	0.864	0.892
Oxy Century TNP	138	No Violation	0 898
Wink TNP	138	No Violation	0.897

The above tables demonstrate the need for the transmission upgrades required to meet the NERC and ERCOT reliability criteria even with the additional generators in Tables 10.1.1 and 10.1.2. Full contingency results can be found in the Appendix.

Further analysis was performed testing these new sensitivity cases with Option 2 improvements applied. There were no criteria violations (under NERC P1, P2-1 and P7 events) seen for Option 2 with the generation sensitivity discussed in this section.

10.2. Load Scaling Impact Analysis

Planning Guide Section 3.1.3(4) (b) requires evaluation of the impact of various load scaling on the criteria violations seen in the study cases. As stated in Section 3.1.1, ERCOT used the 2021 West/Far West (WFW) summer peak case from the 2016 RTP for the steady state analysis. This case was created in accordance with the 2016 Regional Transmission Plan Study Scope and Process document[3], which included load scaled down from the respective non-coincident peaks forecasted in the North, North Central, East, Coast, South, and South Central Weather Zones.

There were four 138 kV thermal violations seen in the steady state analysis as described in Section 4.1 of this report. Power Transfer Distribution Factors (PTDFs) were calculated using PowerWorld Simulator for these four lines using the Far West Weather Zone as the sink, and each of the other seven weather zones individually as the sources. It was found that no matter which other zones were scaled, the PTDFs for each of the lines remained very close. Therefore, ERCOT concluded that the load scaling applied in the cases did not affect the study results. The Appendix contains the PTDFs for each of the four lines under various transfers.

Because the voltage violations were observed at load serving buses, ERCOT assumed that the load scaling in the outside weather zones did not have a material impact on the observed need.

The case used in the dynamic stability portion of the analysis did not contain load scaling, therefore, the observed criteria violations were not affected by load scaling.

[3] http://www.ercot.com/content/wcm/key_documents_lists/77730/2016_RTP_Scope_Process_v1 3_clean.pdf

11. Conclusion

Based on the forecasted loads and scenarios analyzed, ERCOT determined that there is a reliability need to improve the transmission system in Far West Texas. After consideration of the project alternatives, ERCOT concluded that the upgrades identified in Option 2 meet the reliability criteria in the most cost effective manner and have multiple expansion paths to accommodate future load growth in the area of study. Option 2 is estimated to cost $336 million and is described as follows:

- Expand the Riverton Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer.
- Construct a new approximately 85-mile 345 kV line on double-circuit structures with one circuit in place, between Moss and Riverton Switch Station. Add a second circuit to the existing 16-mile Moss Switch Station – Odessa EHV 345 kV double-circuit structures. Install 345 kV circuit breaker(s) at Odessa EHV Switch Station. Connect the new circuit from Riverton Switch Station and terminate at Odessa EHV Switch Station to create the new Odessa EHV – Riverton 345 kV Line.
- Expand the Solstice Switch Station to install a 345 kV ring-bus arrangement with two 600 MVA, 345/138 kV autotransformer.
- Construct a new approximately 68-mile 345 kV line from Solstice Switch Station to Bakersfield Station on double-circuit structures with one circuit in place.

12. Designated Provider of Transmission Facilities

In accordance with the ERCOT Nodal Protocols Section 3.11.4.8, ERCOT staff is to designate transmission providers for projects reviewed in the RPG. The default providers will be those that own the end points of the new projects. These providers can agree to provide or delegate the new facilities or inform ERCOT if they do not elect to provide them. If different providers own the two ends of the recommended projects, ERCOT will designate them as co-providers and they can decide between themselves what parts of the recommended projects they will each provide.

Oncor owns the Odessa EHV Switch Station and the planned Riverton Switch Station. Therefore, ERCOT designates Oncor as the designated provider for the 345 kV Odessa EHV Switch Station to Riverton Switch Station transmission facilities along with the two recommended 345/138 kV autotransformers at Riverton Switch Station.

LCRA TSC owns the Bakersfield Station and AEP Texas owns the Solstice Switch Station. Therefore, ERCOT designates AEP Texas and LCRA TSC as the designated co-providers for the 345 kV Bakersfield Station to Solstice Switch Station transmission facilities along with the two recommended 345/138 kV autotransformers at Solstice Switch Station.

13. Appendix

13.1.	Base Case Violations – Steady State	BaseCaseViolations.xlsx
13.2.	Options Diagrams	Options_Diagrams.pptx
13.3.	Steady State Violations of Project Options	ProjectOptionsViolations.xlsx
13.4.	Violations – Generation Sensitivity Analysis	GenerationSensitivityAnalysisViolations
13.5.	Dynamic Analysis Results	CEII

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Report on Existing and Potential Electric System Constraints and Needs
December 2017

The annual Electric System Constraints and Needs report is provided by the Electric Reliability Council of Texas, Inc. (ERCOT) to identify and analyze existing and potential constraints in the transmission system. This report satisfies the annual reporting requirements of Public Utility Regulatory Act (PURA) Section 39.155(b) and a portion of the requirements of Public Utility Commission Substantive Rules 25.362(i)(2)(I) and 25.505(c).

The transmission system is used to transport power from generators to consumers. When consumers use more power in an area or when the generation fleet changes due to plant retirements or the addition of new resources, the transmission system may need to be upgraded to meet the system needs caused by these changes. Often, these upgrades are needed to meet statutory reliability criteria but can sometimes be required to meet the reliability criteria in a more efficient manner. Insufficient investment in transmission can lead to reliability deficiencies and high congestion costs, which are ultimately borne by the consumers, and can impact external investment in new generation resources or end-use facilities, such as manufacturing plants.

The top two congested constraints on the ERCOT system in 2017 were the North to Houston Import constraint and the Panhandle Export constraint. Both constraints have been highly congested in recent years. Both areas also have projects planned to go into service in 2018 that will help to reduce congestion costs on the system.

Congestion caused by transmission system limitations related to importing power to serve demand in the Houston area from the north was more than twice as high in 2017 as in 2016. This increase in congestion caused the North to Houston Import congestion rent to be the highest in ERCOT for the third straight year. The Coast Weather Zone, which primarily comprises Houston-area demand, topped 20,000 MW for the first time in 2017. The Houston Import Project, which was endorsed by the ERCOT Board in 2014, is expected to go into service in early 2018. Although this project was planned based on reliability needs, it is expected to significantly reduce congestion in the area. Figure ES.1 shows the growth in North to Houston Import congestion since 2012.

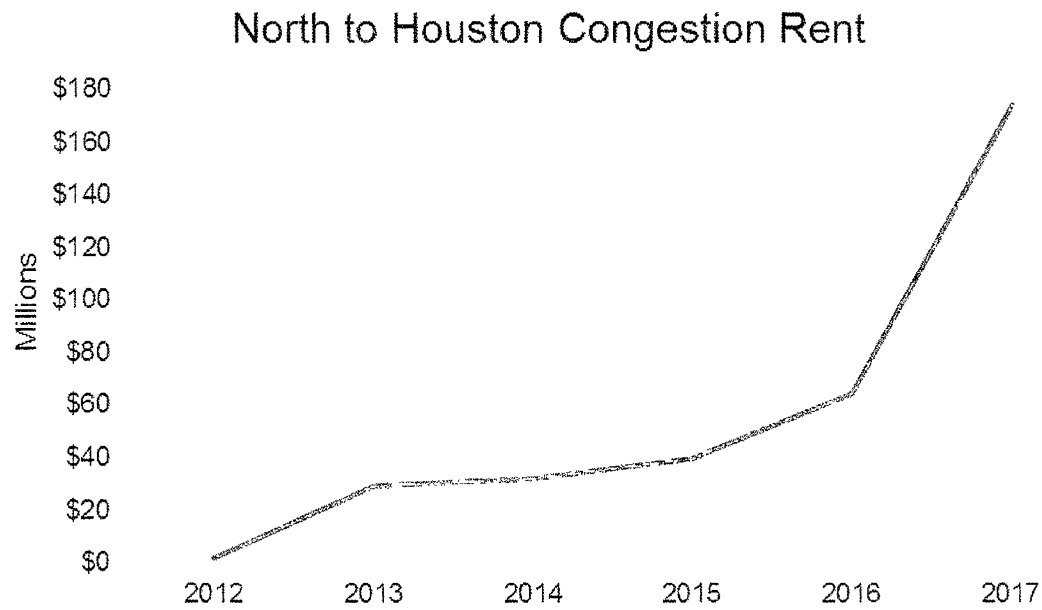

Figure ES.1: North to Houston Congestion Rent by Year

The Panhandle Export Limit constraint exists due to system stability limitations associated with moving large amounts of wind-generated power the long distance from the Texas Panhandle to the load centers in the eastern part of the state. The Panhandle Export Limit had the second highest amount of congestion on the ERCOT system in 2017, up from being the seventh highest amount in 2016. Two Panhandle transmission improvements are currently underway and are scheduled to be in service in early 2018. These improvements are expected to reduce Panhandle Export Limit congestion. However, more wind generation development is planned in the Panhandle, and the Panhandle Export Limit is anticipated to remain one of the highest congested constraints in the ERCOT system over the next six years. ERCOT and Transmission Service Providers continue to evaluate potential transmission projects to relieve this congestion.

In 2012, eight of the top 15 congested transmission elements in ERCOT were in West Texas. With a number of transmission additions and upgrades over the past five years, the amount of congestion in West Texas dropped to two of the top 15 congested transmission elements in 2017. However, the need to expand transmission facilities in West Texas continues due to the load increase related to the oil and natural gas industry and an increase in solar generation development. In fact, the Far West Weather Zone has had the highest peak demand growth rate percentage in the ERCOT region in recent years. Figure ES.2 shows the Far West Weather Zone load growth since 2009.

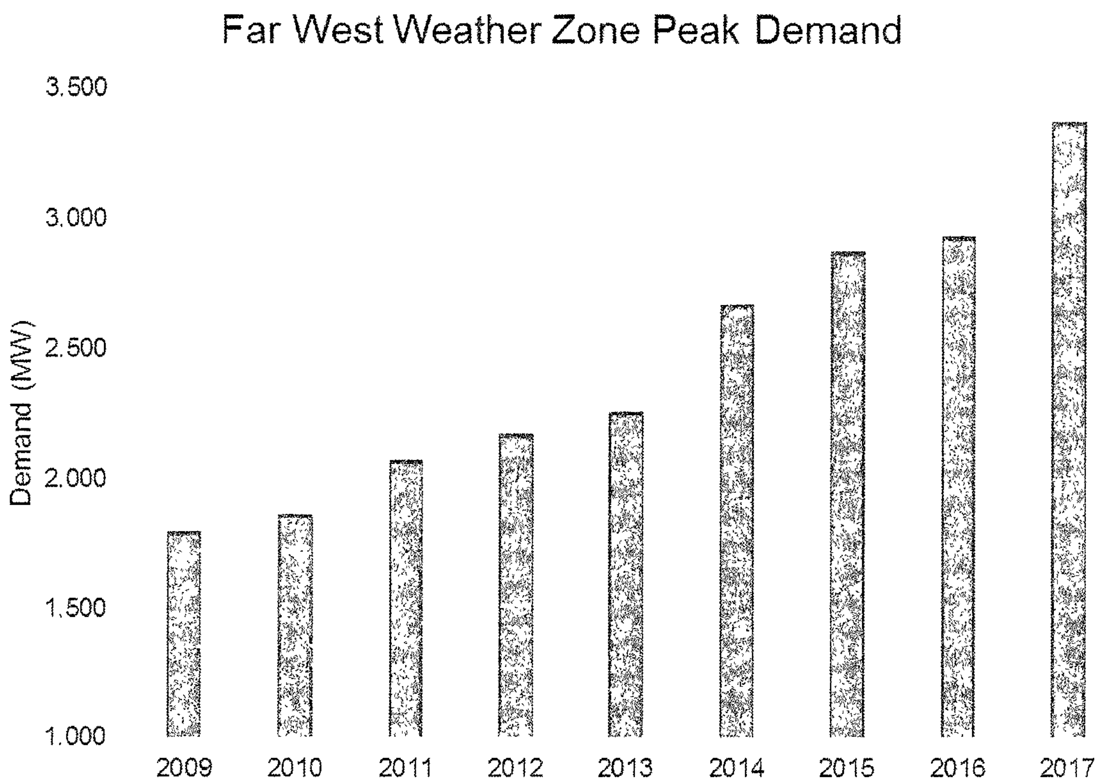

Figure ES.2: Far West Weather Zone Peak Demand by Year

Over the past two years, ERCOT and the Regional Planning Group (RPG) have reviewed and endorsed nearly $600 million of major transmission projects to serve West Texas oil and natural gas-related needs. One of these projects was the Far West Transmission Project, which the ERCOT Board endorsed in June 2017. The project, with an estimated cost of $336 million, will add more than 150 miles of new 345 kV transmission lines in areas with high growth in oil and natural gas related demand.

Another area that has experienced significant load growth recently has been the Freeport area. Due to planned industrial facility additions, including the Freeport Liquefied Natural Gas facility, the Freeport area is expected to see its peak demand increase from less than 800 MW in 2014 to nearly 2,300 MW by 2022. Since 2012, CenterPoint Energy has proposed various transmission upgrade projects in the area to accommodate this growth. In 2017, the RPG reviewed the Freeport Master Plan project, which was designed to meet reliability needs in the area. The ERCOT Board endorsed the need for the project, which includes a new 345 kV line into the Freeport area, in December 2017.

ERCOT performs a biennial Long-Term System Assessment (LTSA) to provide a roadmap for future transmission system expansion and identify long-term trends that should be taken into consideration in near-term planning. The 2016 LTSA identified a future trend of renewable (primarily solar) generation additions to the ERCOT grid corresponding with coal and natural gas generation retirements. In 2017, ERCOT observed several markers that corroborated this trend. First, ERCOT received notification of retirement from the owners of almost 4,800 MW of coal and natural gas generation capacity. While none of the generators requesting to retire was needed to maintain local transmission system reliability, the removal of these generation resources could cause or exacerbate congestion on the ERCOT system.

Second, in 2017 ERCOT received the highest number of requests in a year to study new generator interconnections. The majority of these requests were for new solar generation plants. Currently, there are more than 24,000 MWs of solar generation capacity under study, and approximately 16,000 MWs of that capacity requested study in 2017. Figure ES.3 shows the number of generator interconnection requests received per year, and Figure ES.4 shows the capacity breakdown for the requests received in 2017 (through November). The 2016 LTSA also concluded that this change in the generation mix would drive the need for additional transmission system investment to move the power across the system.

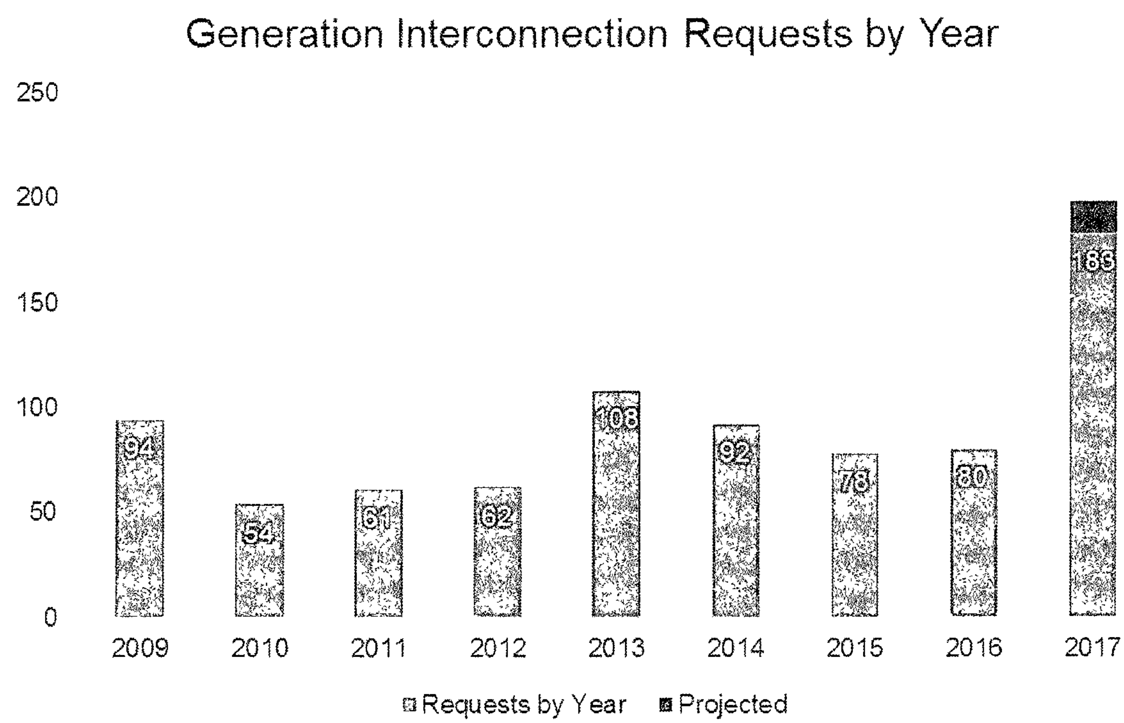

Figure ES.3: Number of Generation Interconnection Requests by Year

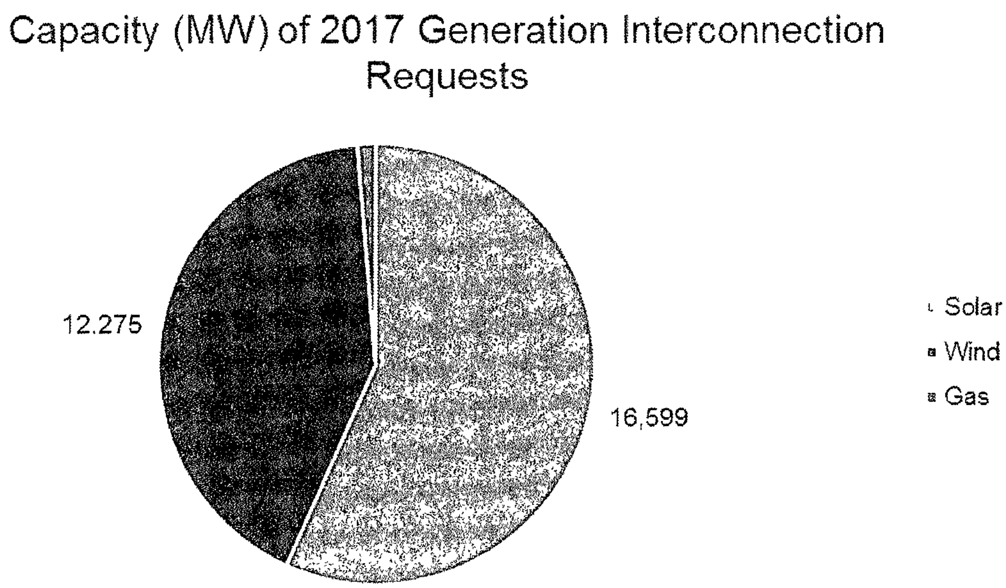

Figure ES.4: Capacity of 2017 Generation Interconnection Requests

In addition to the normal activities of planning for new generation resources and demand growth, ERCOT has performed studies related to the potential moves of Lubbock Power and Light and Rayburn Country Electric Cooperative customers from the Southwest Power Pool grid to the ERCOT grid. ERCOT will continue to provide information to the Public Utility Commission of Texas (PUCT) to support the evaluation of these proposed integration projects as they move through the regulatory process.

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The Electric Reliability Council of Texas (ERCOT), as the independent organization (IO) under the Public Utility Regulatory Act (PURA), is charged with nondiscriminatory coordination of market transactions, systemwide transmission planning and network reliability, and ensuring the reliability and adequacy of the regional electric network in accordance with ERCOT and North American Electric Reliability Corporation (NERC) Reliability Standards. The IO ensures access to the transmission system for all buyers and sellers of electricity on nondiscriminatory terms. In addition, ERCOT, as the NERC-registered Planning Coordinator/ Planning Authority, is responsible for assessing the long-term reliability needs for the ERCOT region.

ERCOT supervises and exercises comprehensive independent authority over the planning of transmission projects for the ERCOT system as outlined in PURA and Public Utility Commission of Texas (PUCT) Substantive Rules. The PUCT Substantive Rules further indicate that the IO shall evaluate and make a recommendation to the PUCT as to the need for any transmission facility over which the IO has comprehensive transmission planning authority. ERCOT examines the need for proposed transmission projects based on ERCOT planning criteria and NERC Reliability Standards. Once a project need has been identified ERCOT evaluates project alternatives based on cost-effectiveness, long-term system needs and other factors.

Transmission planning (i.e., planning of facilities 60 kV and above) is a complex undertaking that requires significant work by, and coordination between, ERCOT, the Transmission Service Providers (TSP), stakeholders, and other market participants. ERCOT works directly with the TSPs, stakeholders, and market participants through the Regional Planning Group (RPG). Each of these entities has responsibilities to ensure that appropriate transmission planning and construction occurs.

The ERCOT Nodal Protocols and Planning Guide describe the practices and procedures through which ERCOT meets its requirements related to system planning under PURA, PUCT Substantive Rules, and NERC Reliability Standards.

Every year ERCOT performs a planning assessment of the transmission system. This assessment is primarily based on three sets of studies.

1. The Regional Transmission Plan (RTP) addresses region-wide reliability and economic transmission needs and includes the recommendation of specific planned improvements to meet those needs for the upcoming six years. The public version of the 2017 RTP report is posted on the ERCOT website at: http://www.ercot.com/news/presentations/.
2. The Long-Term System Assessment (LTSA) uses scenario-analysis techniques to assess the potential needs of the ERCOT system up to 15 years into the future. The role of the LTSA is to provide a roadmap for future transmission system expansion and identify long-term trends that should be taken into consideration in near-term planning. The biennial LTSA study is conducted in even-numbered years. The 2016 Long-Term System Assessment report is posted on the ERCOT website at: http://www.ercot.com/news/presentations/.
3. Stability studies are performed to assess the angular stability, voltage stability, and frequency response of the ERCOT system. Due to the security-related sensitive nature of the information contained in these study reports, they are not published on the ERCOT website.

These Transmission Planning studies are conducted using models that represent expected future transmission topology, demand, and generation. The models are tested against reliability and economic planning criteria per NERC Reliability Standards and the ERCOT Protocols and Planning Guide. When system simulations indicate a deficiency in meeting the criteria, a corrective action plan is developed; this corrective action plan typically includes a planned transmission improvement project. TSPs also perform studies to assess the reliability of their portions of the ERCOT system.

Transmission system improvements are built by TSPs and are paid for by consumers. During the twelve-month period from October 2016 through September 2017, TSPs completed $1.09 billion worth of transmission improvement projects. Figure 2.1 shows the cost of transmission improvements completed in ERCOT, by calendar year, from 2007 through 2016. The cost is separated by Competitive Renewable Energy Zone (CREZ)-related projects and non-CREZ-related projects. The non-CREZ-related transmission improvement costs in 2016 were notably higher than previous years due, in part, to the completion of two large projects located in the Lower Rio Grande Valley that accounted for approximately $649 million of the total.